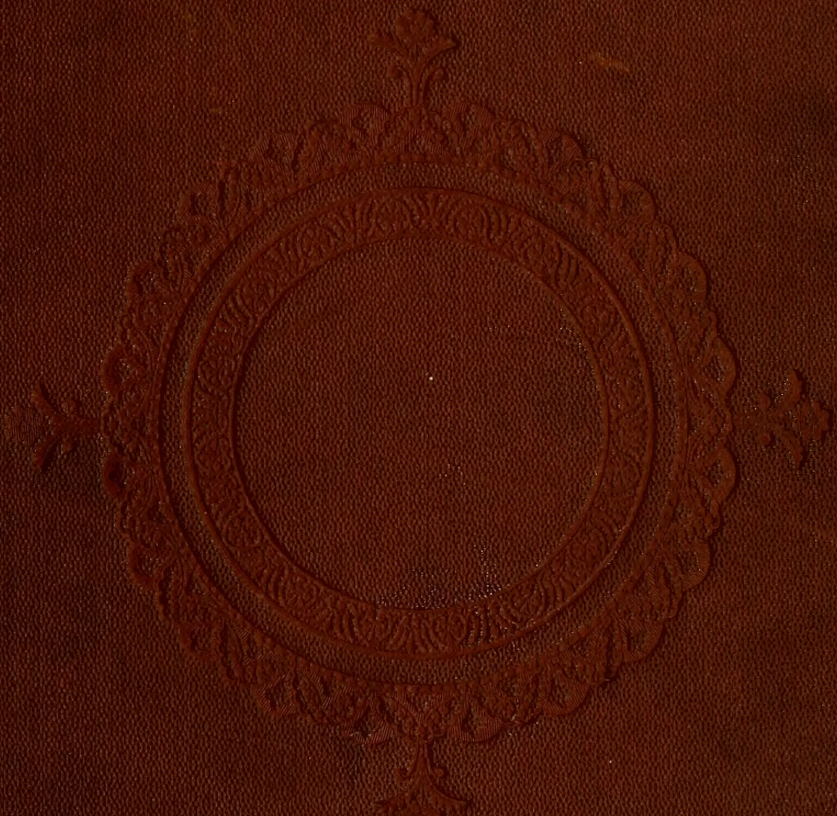

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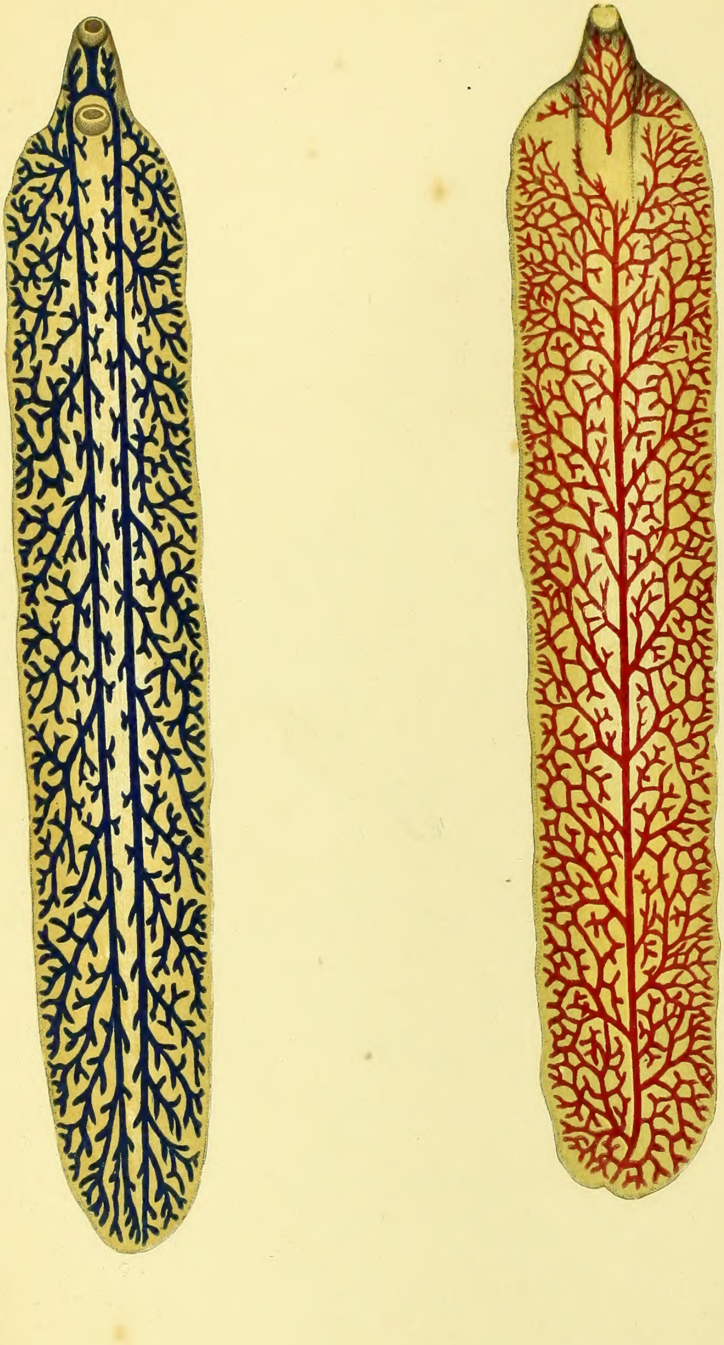

Fasciola gigantea, Cobbold.
Magnified 2¼ diameters.
T. S. C. delt.

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ENTOZOA:

AN INTRODUCTION

TO THE STUDY OF

HELMINTHOLOGY,

WITH REFERENCE, MORE PARTICULARLY, TO

THE INTERNAL PARASITES OF MAN.

BY

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DEDICATION.

TO GEORGE BUSK, Esq., F.R.S.

Dear Mr. Busk,

I request you to accept the dedication of this Elementary Treatise on a subject which so much engaged your attention during the earlier period of your scientific career.

The advice and encouragement received at your hands during several years past have materially aided me in the prosecution of those entozoological investigations which form the basis of this volume; and, but for the important series of drawings which your skilful pencil and disinterested kindness have supplied, the work, as it now stands, must have been deprived of one of its most attractive features.

I am, dear Mr. Busk,

Yours very truly,

T. SPENCER COBBOLD.

London [illegible] Medicine

PREFACE.

WITHOUT any customary apology, either to the general public or to the members of the medical profession, I introduce this elementary treatise.

On all hands it is conceded that the subject of Entozoology has an important bearing on questions affecting the maintenance of public health; and it is to be regarded as a matter of congratulation that the political economist of the present day not unfrequently avails himself of the labours of the scientific naturalist.

Since the publication of Mr. Rhind's small volume on the internal parasites of the human body, so far back as the year 1829, I am not aware that any complete work of a similar kind has been written by any English author. It is true that we are in possession of several original and extremely valuable memoirs which will bear advantageous comparison with the more numerous *brochures* issued in foreign lands; but, as regards works designed to embrace the study of Helminthology, in its entirety, no such project has hitherto been attempted. The void, however, has been more or less completely occupied by several able translations. First and foremost among these is the Sydenham Society's edition of Küchenmeister's standard work on the "Animal and Vegetable Parasites of the Human Body," by Dr. Lankester, F.R.S. Secondly, we are presented with a tolerably comprehensive outline both of the external and internal parasites of man, in Mr. Hulme's edition of Moquin-Tandon's useful little book, entitled *Eléments de Zoologie Médicale.* Thirdly, we are furnished with an excellent account of the general organization of the Helminths and Turbellarians in the fifth and sixth sections of Dr. Burnett's American edition of Von Siebold and Stannius' *Lehrbuch der vergleichenden Anatomie;* and, fourthly, there is Dr. W. A. Smith's recently issued volume "On Human Entozoa," which is, for the most part, an agreeable and practical excerpt from Davaine's remarkable *Traité des*

Entozoaires et des Maladies Vermineuses de l'Homme et des Animaux Domestiques. Besides these, it may not be out of place to particularize Prof. Huxley's translation of Von Siebold's memoir on Tape and Cystic Worms (*Band und Blasenwürmer*), and especially, also, Weinland's "Essay on the Tapeworms of Man," written in the English language by its accomplished author. In respect of original contributions on Entozoa, it were almost invidious to refer to particular articles and papers; yet I may, perhaps, be permitted to acknowledge the pleasure and profit I have derived from a perusal of the writings of Owen, Busk, Huxley, Thomson, Nelson, Carter, and Bastian.

The engravings of this work have been executed with great care. The twenty-one Plates comprise one hundred and fifty-six separate figures, which, with eighty-two Woodcuts, make a total of two hundred and thirty-eight Illustrations. Of these, one hundred and five are derived from original sources; forty-three are taken from drawings executed by Mr. Busk; twenty-four are small figures, in one Plate, from Nelson; nineteen, mostly large Woodcuts, from Leuckart; thirteen, more or less completely, from Blanchard; six from figures by the late Professor W. Smith, of Cork; six from Van Beneden; four from Küchenmeister; three from Huxley; two from Eberth; and one each from Van Ammon, Wilson, Rokitansky, Bristowe and Rainey, Curling, Claperède, Hulke, Lubbock, Bastian, Knoch, J. Harley, and Mosler. To this list may be added also the illustration so ably executed by Mr. Jennens (at p. 124) from a photograph by Dr. Hallifax of Brighton.

The extended Bibliography attached to this work is the result of a laborious search after entozoological facts, scattered through upwards of twelve hundred British and American volumes. No one, who has not gone over our home literature after this fashion, could have believed what a multitude of valuable and instructive data lie concealed within the shelves of our public libraries.

To the council of the Royal College of Surgeons of England, and to Mr. Chatto, their obliging Librarian, I am greatly indebted for the liberal manner in which I have been permitted access to their library; and only in a less degree are my obligations due to Professor James Beart Simonds, of the Royal Veterinary College, for the free use of his private and valuable collection of professional works. The libraries of the Linnean and Zoological Societies, as well as those of the Middlesex Hospital Medical College and Royal Medico-Chirurgical Society, also supplied me with useful references.

As regards foreign literature, I have scarcely had occasion to go beyond the tolerably complete collection of works which (thanks to the vigilance of Messrs. Williams and Norgate) my private shelves contain; but, in this connection, I beg to offer my acknowledgments to D. F. Weinland of Frankfort, C. M. Diesing of Vienna, E. Claparède formerly of Geneva, and R. Leuckart of Giessen, for their kindly gifts.

T. S. C.

MIDDLESEX HOSPITAL MEDICAL COLLEGE, LONDON,
September, 1864.

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List of Works, Memoirs, and Communications on the subject of Internal Parasites, which have appeared in the English language during the last half century. 421

DESCRIPTION OF PLATES.

FRONTISPIECE.

THIS plate represents two different examples of a large fluke (*Fasciola gigantea*, Cobbold) taken from the biliary ducts of the liver of a giraffe (× $2\frac{1}{4}$ diam.).

The specimen to the left has the anterior surface exposed, so as to display the oral and ventral suckers, and, more particularly, the dendriform digestive apparatus which has been injected from the mouth by artificially prepared ultramarine.

The figure to the right exhibits the dorsal aspect of the other specimen, showing, more especially, the multi-ramose character of the water-vascular system, the vessels of which have been distended with vermilion.

The direction of the primary branches of the two canal-systems forms a complete contrast.

The original preparations and drawings from which these figures have been taken, are in the author's possession.—T. S. C.

PLATE II.

FIG.

1. Eight examples of a small fluke (*Distoma conjunctum*, Cobbold) obtained from the liver of an American red fox (*Canis fulvus*) ; the central pair being sexually united. Natural size.
2. One of the same, coloured to render the parts more distinct (× 35 diam.) ; *a*, oral sucker ; *b*, acetabulum ; *c*, œsophageal bulb ; *d*, *d*, digestive canals ; *e*, reproductive papilla ; *f*, commencement of the uterus ; *g*, ovary, with two excretory ducts coming from the vitelligene, or yelk-forming glands ; *h*, *h*, primary branches from the main trunk of the water-vascular system ; *i*, *i*, the vitelligenes ; *k*, *k*, testes ; *l*, contractile vesicle.
3. Group of ova. Slightly magnified.
4. Three of the same, showing the opercula, segmented yelks, and granular contents escaping from the lowermost specimen (× 150 diam.).
5. Mass of glittering corpuscles from the interior of the contractile vesicle (× 250 diam.).

The above figures are from original sources.—T. S. C.

PLATE III.

FIG.

1. Sexually mature example of *Amphistoma conicum*, magnified about 12 diam. It exhibits the oral and caudal suckers, the intestinal cœca (coloured blue), the uterine canal (yellow), the nervous collar and so-called cerebral ganglia, and, more particularly, the complicated system of water vessels (red). —After Blanchard.
2. Another specimen (× 2 diam.) with the dorsal surface exposed.—Blanchard.
3. The same viewed laterally.—Blanchard.
4. Part of the female series of reproductive organs, isolated to show the connection of the vitelligene glands with the ovary and with the uterus (× 12 diam.).—Altered from Blanchard.
5. Male reproductive organs (× 12 diam.).—Altered from Blanchard in accordance with an original dissection.
6. Egg of an Amphistoma taken from the paunch (rumen) of a zebu, formerly living in the Zoological Society's Menagerie, Regent's Park (× about 80 diam.).—Original.
7. Seminal corpuscles from the testis (highly magnified).—After Blanchard.

PLATE IV.

1 and 2. Two examples of *Oxyuris curvula* from the large intestine of the horse. Females. Natural size.

3. Section of the anterior part of the body of one of the above, showing the fine transverse rings and conical form of the head. Slightly magnified.
4. Another view of part of the head, showing the oral aperture, the transverse striæ, and, more particularly, the elastic denticles (*houppes de poils ou cirrhes flottants* of Dujardin) projecting from the pharynx (× 60 diam.).
5. An egg taken from the smaller of the two worms. Highly magnified.
6. Vegetable débris from the intestine canal of one of these Oxyures; *a*, hair constricted at the base; *b*, elongated epidermic cell; *c*, oval parenchymatous cell; *d*, *e*, simple unicellular hairs; *f*, fringed epidermic cellular tissue; *g*, spiral fibre. Highly magnified.

These figures are copied from drawings executed by Mr. Busk.

PLATE V.

1. Two examples of the whipworm (*Trichocephalus affinis*, Rudolphi) from the cœcum of a young giraffe which died in the Zoological Society's Menagerie, Regent's Park. The upper one a female, the lower a male. Slightly enlarged.
2. Head of the male specimen, showing the spurious winged appendages on either side of the mouth (× about 200 diam.).
3. Section of the neck: *a*, longitudinal band of epidermic cells; *a'*, four of the same isolated and seen under an altered focus; *b*, fold of the œsophagus; *c*, *c*, transverse striæ; *d*, *d*, oval corpuscles (× 230 diam.).

FIG.

4. Enlarged view of the spirally folded caudal extremity of the male Trichocephalus.
5. Part of the same, more highly magnified, to show, *a*, protrusor muscle; *b*, cloacal aperture; *c*, sheath of the penis or *appendix copulatorius* (× 110 diam.).
6. Exserted membranous vulva, showing the vaginal passage and retroverted spines (× 140 diam.).
7. Four unimpregnated ova (× 220 diam.).
8. Fully developed egg with a bisegmented yelk and highly refracting nuclei (× 180 diam.).

These figures are original.—T. S. C.

PLATE VI.

1. Head of a male specimen of *Prosthecosacter convolutus* (magnified 60 diam.), which measured fifteen lines in length. From the lungs of the common porpoise. The œsophagus and upper part of the intestinal tube are seen through the integument.
2. Caudal extremity of the same worm, showing the intromittent organ and accessory appendages. Viewed from behind (× about 60 diam.).
3. A more highly magnified representation of the tail of the male seen from the so-called ventral aspect. It exhibits the great lateral membranous appendages in their fully expanded condition, a small pair succeeding them, the terminal lobes surrounding (with their contained muscular organs) the cloacal orifice, the sheath of the penis, the double intromittent organ, and the lower part of the alimentary canal (× 220 diam.).
4. *Prosthecosacter convolutus.* Female. Natural size.

These figures are from drawings by Mr. Busk.

PLATE VII.

1. Anterior extremity of a female example of *Prosthecosacter convolutus* (magnified 60 diam.).
2. Caudal extremity of the same, showing numerous embryos in the interior (× 60 diam.).
3. Another view of part of the same, showing the prominent lateral vesicle, the uterine canal, and a young embryo in the act of escaping *per vaginam* (× 220 diam.).
4. Section of the uterus, with contained ova in various stages of development (× 220 diam.).
5. One of the free embryos isolated (× 350 diam.).

These figures are from drawings by Mr. Busk.

PLATE VIII.

1. Section of the intestinal tube of the speckled salamander (*Lissotriton punctatus*), laid open to exhibit the mode of attachment of *Echinorhynchus anthuris* to the mucous surface. Natural size.

FIG.

2. Male *Echinorhynchus anthuris* (× 8 diam.).
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7. Another example viewed laterally.
8. Ovum separated from its primitive envelope, showing the shell (chorion), and superfluous yelk mass still adherent. (The last six figs. × 350 diam.)
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11. *Echinorhynchus nodulosus*, from a small trout. Natural size.
12. The same (× 12 diam.).
13. Two eggs of *E. nodulosus*, showing their peculiar form and circumscribed yelk contents (× 1000 diam.).

Figures 1 to 8 inclusive are from original sources (T. S. C.), the remainder from drawings by Mr. Busk.

PLATE IX.

1. Cyst from beneath the peritoneal surface of the intestine of a haddock. (Natural size.)
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6. One of the calcareous particles from the caudal vesicle (× 200 diam.).
7. Section of a proboscis, showing the peculiar arrangement of the hooks and hooklets. The figure marked *e* represents a series of delicate anastomosing canals seen beneath the integument at the lower part of the body in front of the caudal vesicle.

These figures are original.—T. S. C.

PLATE X.

1. Outline of the dissection of a young sun-fish (*Orthagoriscus mola*), showing several *Tetrarhynchi* lodged within cysts imbedded in the retractor muscles of the anal fin. Reduced to one-sixth of the natural size.
2. The so-called head, neck, subcervical enlargement, and upper part of the body of *Tetrarhynchus reptans* inclosed in its transparent sheath. Enlarged one-third.
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FIG.

4. A few articulations or sexually immature proglottides from the lower part of the body. Natural size.
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7. One of the large hooks (× 260 diam.).
8. One of the small hooks (× 260 diam.).
9. Head of *Tetrarhynchus reptans* viewed from above (× 8 diam.).

These figures are original.—T. S. C.

PLATE XI.

1. A mature specimen of *Fasciola hepatica* seen from the ventral aspect (× 6 diam.). After Blanchard.
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3. Diagram of the water-vascular system (× 2 diam.). Original.
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6. Upper part of the male reproductive apparatus. Altered from Küchenmeister.
7. Egg of *Fasciola hepatica*, showing the so-called mulberry stage of yelk-segmentation. Original.

PLATE XII.

1. Head, neck, and upper joints of *Tænia solium*. Reduced from Blanchard.
2. One of the lower or sexually-mature joints of the same, showing the water-vascular canals and the branched uterine organ distended with ova. After Blanchard.
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11. A fully-developed *Cysticercus cellulosæ*, taken from fresh pork. (Natural size.) From a figure by the late Professor Smith, of Cork.
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14. Head and body withdrawn from the caudal vesicle. Smith.
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PLATE XIII.

1. Juvenile hydatid, about six weeks old (× 50 diam.). From a specimen reared by Leuckart, and now in the Author's collection. Original.

FIG.

2. Portion of a large hydatid from a cyst in the human liver. Part of a specimen preserved in the Middlesex Hospital Museum. Dr. Murchison's case. Coloured naturally by bile. Original.
3. Similar portion of another human hydatid, artificially coloured with magenta. Dr. Greenhow's case. Specimen preserved in the same museum. Original.
4. Scolex, or one of the Echinococcus heads, showing, more particularly, the hooks, suckers, and calcareous particles. From a zebra (× about 500 diam.). After Huxley.
5. Two of the hooks separated; one seen in profile, the other in front. Huxley.
6. An entire sexually mature *Tænia echinococcus*, showing the head, with rostellum and suckers, and the three succeeding segments, the last of which contains the ova and other reproductive elements. The water-vascular system is likewise displayed. Outlined, with the aid of a camera, from a specimen prepared by Leuckart, and now preserved in the Author's collection. (Magnified 30 diam.) Original.

PLATE XIV.

1. A detached and flattened Echinococcus brood-capsule, showing the scolices in various stages of development, and their attachment, *in situ*. Taken from an hydatid found in the pig.—Busk.
2. An imperfectly developed scolex, from the same.—Busk.
3. One of the smaller hydatids, or so-called daughter vesicles in process of degeneration. The partially disintegrated scolices and separated hooks are seen in the interior.—Busk.

PLATE XV.

1. Group of Echinococci attached by their pedicles to a portion of the collapsed wall of a brood-capsule; all the heads and cephalic hooks remaining inverted. From the hydatid of a sheep.—Busk.

2—7. Six scolices in various stages, separated from an hydatid occupying the human liver. They floated loosely in a bright yellow-coloured fluid, distending the maternal cyst.—Busk.

PLATE XVI.

1. A full-grown male specimen of *Ascaris lumbricoides*; showing, especially, the prominent mouth and double spiculum. Natural size.
2. Head of the same, exhibiting the form and position of the separate lobes of the lip (× 10 diam.)
3. Tail of the male (× 10 diam.).
4. Tail of the female (× 10 diam.).
5. Vas deferens, seminal reservoir, and pouch for the spicules. Slightly enlarged from a dissection.
6. Uterus, uterine horns, and commencement of the oviducts. Slightly enlarged.

The above figures are original.—T. S. C.

PLATE XVII.

FIG.

1. Nucleated germs fromthe cœcal extremity of the ovarian tube of *Ascaris mystax.*
2. Pedunculated ova at an early stage of development.
3. Two similar ova of a triangular form and further advanced.
4. Unimpregnated ovum still further developed.
5. Ovum " during fertilization, whose vitellus is much broken up by the spermatic particles."

6—17. Impregnated eggs in various stages of development during the process of yelk-segmentation.

18—24. Similar series, showing the finely granular yelk gradually developing itself into a vermiform embryo.

The above figures are from Nelson; being the same as those selected by Prof. J. Hughes Bennett to illustrate his first Lecture " On Molecular Physiology," etc., published in the " Lancet," for Jan. 3rd, 1863. Figs. 1—3 are × 330 diam.; the remainder × 220 diam.

PLATE XVIII.

1. Head of *Oxyuris vermicularis*, showing the exserted trilobular lip, the commencement of the pharynx, the transverse lines, and, more particularly, the lateral winged-appendages (× 220 diam.).
2. Head, neck, and upper part of the body of the same, exhibiting the retracted mouth, the lateral alæ, the transverse markings of the integument, and, more especially the pharynx, œsophagus, and upper part of the intestinal canal (× 220 diam.).
3. Section of the body of the same, showing ova within the uterine canal, and the mode of termination of the vaginal passage (× 110 diam.).

These figures are from drawings by Mr. Busk.

PLATE XIX.

1. A female *Oxyuris vermicularis*, displaying the normal position of the digestive and reproductive organs, and the points at which their several outlets terminate (× 20 diam.).
2. Oral extremity of the same, showing the partly protruded lips, the lateral alæ, and pharyngeal muscles (× 450 diam.).
3. Section from the lower part of the body, exhibiting the mode of termination of the intestinal canal, and, more particularly, numerous ova lodged within, in the folded extremity of one of the uterine horns (× 220 diam.).
4. Four ova; *a*, showing the commencement of the embryonic formation, and *b*, *c*, *d*, the completed tadpole-shaped embryo in their interior (× 450 diam.).—Original.

Figs. 1 to 3, inclusive, are from drawings by Mr. Busk.

PLATE XX.

FIG.

1. A female example of *Dracunculus medinensis* of the natural size.
2. Caudal extremity of the same; considerably magnified.
3. Enlarged view of the head, showing its truncate form and the position of the equidistantly situated cephalic papillæ; magnified.
4. View representing the field of the microscope with numerous embryos in focus. Drawn with the aid of a camera (× 60 diam.).
5. One of the embryos naturally coiled upon itself (× 500 diam.).

The above figures are original.—T. S. C.

PLATE XXI.

1. A male example of *Pentastoma tænioides.* Natural size.
2. A female specimen of the same worm. Natural size.
3. Upper fourth of the body of the so-called *Pentastoma denticulatum,* showing the mouth, cephalic claws, integumentary spines, stigmata, and internal glandular parenchyma (× 60 diam.).
4. One of the claws isolated; *a,* moveable hook; *b,* tubular portion of the capsule; *c,* longitudinal groove; *d,* hood; *e,* the three-cornered point-cover; *f,* extensor, and *g,* retractor muscles of the hook (× 100 diam.).
5. Diagram of a portion of integument (with the spaces between the rows of hooks shortened); *a,* spines; *b,* stigmata (× 250 diam.).
6. Parenchymatous glandular cellules (× 220 diam.).
7. Egg of *Pentastoma tænioides,* with its contained embryo.—Leuckart.
8. Embryo of the same after its escape from the egg.—Leuckart.

Figs. 1 to 6, inclusive, are original.—T. S. C.

ERRATA.

In the first sheet of this work, the scholar will readily notice the omission of several Greek accents, as, for example, at page 1, in the words ελμινθες, λογος, and εντος, ζωον, λογος, for which *read*, ἕλμινθες, λόγος, and ἐντὸς, ζῶον, λόγος. Similar omissions occur at pages 6 and 7. I believe the *ü* in Küchenmeister is at least once printed without its proper vowel indication, whilst (at page 11) an accent has erroneously been allowed to stand over the last syllable in the name Rathke. A more unfortunate typographical error occurs at the lower part of Plates No. vi. and vii., where the generic word Prosthecosacter is wrongly printed Prosthecosacta.

T. S. C.

PART I.

SYSTEMATIC HELMINTHOLOGY;

OR A GENERAL ACCOUNT OF THE HABITS, STRUCTURE, DEVELOPMENT,
AFFINITIES, DISTRIBUTION AND CLASSIFICATION OF THE
ENTOZOA AND THEIR ALLIES.

24 SEP.

ENTOZOA.

CHAPTER I.

HELMINTHA.

Nature and extent of the subject—Leading terms employed—The Entozoa constitute a peculiar *fauna*—Their distribution throughout *time* and *space*—Not yet found in a fossil state—Classification of the Helminths—A new sub-class proposed—The Turbellarians—Characters of the Planaridæ—Genera—The Nemertidæ, or ribbon worms—Their structure and habits—Genera—Concluding argument in favour of associating the Turbellarians with the Helminths in the manner here proposed.

Of late years no department of Natural History science has attracted more attention than that of the study of internal parasites, and it may also be affirmed that no separate branch of biological inquiry has in recent times advanced more rapidly.

The study of the internal parasites of man and animals is one of boundless extent, and from the multiplicity and variety of creatures thus found associated by one common habit of life, zoologists have deemed it not only advantageous, but even absolutely necessary to consider them collectively in the light, as it were, of a separate science. To this science the appropriate title of *Helminthology* (ελμινθες—λογος) has been given; but the term *Entozoology* (εντος—ζωον—λογος) is nearly equivalent, and may be conveniently substituted when occasion offers.

Helminthological science makes us acquainted with the forms, habits, structure, development, distribution, and classification of a multitude of evertebrated organisms which take up their abode, at one or more periods of their lifetime, in the bodies of man and animals. To this rule there are a few exceptions, and in some instances the helminths remain parasitic externally, so that, in one sense, they become ectozoa rather than entozoa. Of this kind the genera *Gyrodactylus*, *Diplozoon*, and *Tristoma* afford characteristic examples.

I have already hinted that the entozoa or helminths display a considerable variety of character. So much, indeed, is this the case that many naturalists protest against the common habit of placing all the internal parasites in a separate class. Doubtless there are legitimate grounds for this protest; but, after a prolonged examination of the question, I have satisfied myself that the method of retaining the entozoa as a distinct group is fraught with advantages more than counterbalancing the apparent orthodoxy which a rather more exact and systematic treatment of the subject might involve.

The happiest, and perhaps after all, the most truly philosophic way of studying the entozoa is to regard them as a peculiar *fauna*, destined to occupy an equally peculiar territory. That territory is the widespread domain of the interior of the bodies of man and animals. Each animal or "host" may be regarded as a continent, and each part or viscus of his body may be noted as a district. Each district has its special attractions for particular parasitic forms; yet, at the same time, neither the district nor the continent are suitable localities as a permanent resting-place for the invader. None of the internal parasites "continue in one stay;" all have a tendency to roam; migration is the very soul of their prosperity; change of residence the *sine quâ non* of their existence, whilst a blockade in the interior, prolonged beyond the proper period, terminates only in cretification and death.

The above-mentioned phenomena will scarcely fail to suggest, also, several peculiarities respecting the distribution of these creatures; for it is obvious that their disposition throughout *space* will be co-extensive with the geographical range of the "hosts" in which they dwell, and it therefore probably follows that they must also acquire a corresponding distribution in *time*.

Their bathymetric position or distribution in height and depth in relation to our planet, will likewise accord with that of the infested animals; so that, in short, the length, breadth, and area of their geological and geographical range will be identical with that of the vertebrate groups whose individual bodies they inhabit.

The truth of this general proposition, taken merely as an hypothesis, can scarcely be assailed; yet, I have not omitted to seek diligently for practical evidence of the existence of internal parasites in ancient times. This I have done by scraping down portions of fossil excrement, submitting the same to microscopic observation, in the hope of stumbling upon a parasite's hook or spine. Of course a search of this kind could scarcely be expected to prove effective, because the delicate structure of the entozoa, the minuteness of their bulk, and, more particularly, the extreme rarity of their being mixed with the eliminated contents of the alimentary canal, at once suggest almost insuperable barriers in the way of success. I do not yet despair, however, of recording ocular proof of the occurrence of entozoa in the secondary and tertiary epochs.

For the reasons already stated, it is not my intention to break up the helminths into separate animal groups, but to retain them as a single class, forming the lowermost section of the articulate division of the animal kingdom. Certainly the majority of the helminths conform to the annulose type, and I cannot but regard those views as fanciful which would place the Cestodes among the Radiaria; especially, since this idea is based chiefly on the radiated character of the so-called tapeworm head. At all events, every attempt to distribute the entozoa amongst the different invertebrate groups to which they are supposed to be most closely allied, has hitherto been attended with endless confusion; therefore, in the present state of our knowledge, it is manifestly prudent to continue the method actually thrust upon us by experience. In this view I offer the following scheme of classification which, in some important details, will be found to depart from the plans generally in vogue :—

HELMINTHA (Class.)	STERELMINTHA (Sub-class I.)	*Turbellaria* (Ord. 1).	
		Trematoda (Ord. 2).	ENTOZOA.
	CŒLELMINTHA (Sub-class II.)	*Nematoda* (Ord. 3).	
	ANENTERELMINTHA (Sub-class III.)	*Acanthocephala* (Ord. 4).	
		Cestoda (Ord. 5).	

In this scheme it will be noticed that I have not hesitated, on the one hand, to place the Turbellaria amongst the solid or parenchymatous helminths (*sterelmintha*, Owen ; στερεα—ελμινθες) ; whilst, on the other hand, I have formed a new sub-class for those helminths which are not provided with an intestinal canal (*anenterelmintha ;* α—εντερον—ελμινθες).* The hollow or cavitary group stands as before (*cœlelmintha,* Owen ; κοιλη—ελμινθες). In regard to the first change here proposed, I may remark that the Turbellaria come nearer to the Trematoda than they do to the suctorial annelids ; which latter, be it remembered, are furnished with a complete intestinal tube and anus, and, moreover, their characters, by the intervention of the planariæ, are too closely linked on to the Trematoda to permit of their being elevated by themselves into a separate class. Von Siebold, however, has done this, in my opinion, on insufficient grounds ; but it is not unlikely that he would, in opposition to the views here advanced, urge the impropriety of calling the Turbellaria true helminths. In reply, I should be ready to admit that the Turbellaria are not helminths in the same sense as the entozoa, properly so called, but by imparting to the term helminth a wider signification than that to which it was restricted both by Aristotle and Hippocrates—for they employed it, technically, as equivalent to the intestinal worms—we come to a fairer interpretation of the original Greek root (ειλεω) from which the noun itself (ελμινς) is derived. At the same time, we legitimately permit greater scope to the class-title, at once simplifying the scheme of classification without disturbing the recognized affinities of its subdivisions.

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* Since the above was written, Prof. Leuckart (on showing him the M.S.) drew my attention to the circumstance that he had some years back employed the term *Anenterata* to include the *Acanthocephala* and *Cestoda.* He referred me to Carus (*System der Thierischen Morphologie,* s. 417), where I find the term in question adopted.—T. S. C.

In regard to the proposal of a new sub-class, this I conceive to be a still more important desideratum; for, not a few zoologists still cling to the very erroneous notion that the Cestoda and Acanthocephala are furnished with a digestive apparatus, whereas, both these orders together constitute a group of entozoa quite distinct from the Sterelmintha and Cœlelmintha. Neither the thorn-headed worms nor the tape-worms are supplied with any mouth or intestine, but their nourishment is obtained by a vicarious process of imbibition through the general surface of the body.

Having thus offered a simple and, I trust, a useful scheme of classification, and having briefly explained my reasons for its adoption, I proceed, without further prelude, to take up the various groups as they occur in the scheme, commencing with the first order, namely, the Turbellaria, which may be arranged as follows:—

TURBELLARIA { *Planaridæ* (Family I.)
Nemertidæ (Family II.)

The Turbellarians were first collected into a single group by the distinguished naturalist Ehrenberg, who recognized the presence of vibratile cilia over the entire surface of their bodies. This important character was found to be common to all the members of the group, and in consequence of the peculiar rotatory motion communicated to the water whilst the animals were in the act of swimming, the ordinal title in question was imparted to them. Different writers have since employed the term Turbellaria in a more or less restricted sense, as compared with the original value imparted to it by Ehrenberg; but, on the whole, the modifications adopted by Oersted of Copenhagen may be regarded as the most satisfactory.

In common with the Trematoda, the Turbellarians have their bodies composed of soft parenchymatous tissue, and in this loose substance the various specialized organs are lodged without the intervention of any perivisceral cavity. Some of the animals have a flattened form, others are cylindrical, whilst a third kind are remarkably attenuated, and more or less barred by transverse rugæ, which form, as it were, a series of spurious joints or articulations. The mouth and digestive apparatus are well developed, but there is no certain evidence as to the existence of an anus in any of the species.

Planaridæ.—The resemblance of the individual members of this family to the common liver fluke is very striking, not only in the matter of external form and aspect but also as regards the conformation of the intestinal system, which is essentially dendritic or multiramose. In the group termed Dendrocœlians by Oersted, we have a smooth, flat, inarticulate body, and a capacious mouth, which is situated on the ventral aspect, leading to a large stomach, the latter giving off a series of regularly branching cœca. The nervous system is well developed, the two cerebral ganglia transmitting filaments to the eyes or ocelli, which in some of the species are very numerous (*Planaria*, *Eolidoceros*), whilst in others there are but two (*Mesostoma*). The male and female reproductive organs are conspicuous, as obtains in the hermaphroditic trematodes, the outlets of these organs being generally separate and distinct. A water-vascular system has been described by several observers (Siebold, Ehrenberg), but its existence has been either doubted or altogether denied by others.

The power of reproduction in the Planarians is very striking, but their mode of development is as yet only very partially understood. Beside the ordinary mode of sexual increase, some species propagate by natural fission, and in this latter method almost any fragment of the body seems capable, on being cast off, of realizing an independent existence. Sir John Graham Dalyell saw one individual (*Planaria nigra*) voluntarily decapitate itself, and by artificial experiment he has also shown that "innumerable sections of the body" in this species are all capable of becoming "complete and perfect animals." Other observers, such as Dugès and J. R. Johnson, have obtained similar results. As regards their development from the egg much remains to be done, but Agassiz states that the infusorial genera *Kolpoda* and *Paramecium* are only embryos of Planaria. According to Von Siebold, the eggs are multiple (as occurs in certain tapeworms—*Tœnia cucumerina* for example), and develop several embryos simultaneously. These embryos subsequently become clothed with cilia, and without any alternation of generation ultimately acquire the form and structure of their adult progenitors.

As above indicated, all the true Planarians (*Dendrocœla*) display a branched digestive tube, but a second group of the family (*Rhabdocœla*) have a simple intestine, combined with a closer union of the male and female reproductive organs, except in one genus (*Dinophilus*) where the sexes are altogether separate. In other words, the sexual systems are so united that they present only a single outlet, as may be seen, for example, in the well-known genus *Mesostoma*, which may be taken as a type of the rhabdocœlian group. The different species of this genus vary from three or four lines to about three quarters of an inch in length, and, according to the observations of Focke, they are capable of throwing themselves into an endless variety of forms, occasionally folding their lateral borders in such a manner that the body becomes doubled, as it were, somewhat after the fashion of the Siamese twins.*

Genera.—Dendrocœlian group.—*Planaria*, O. F. Mueller (in part), Ehrenberg; *Monocelis*, Ehrenberg, Oersted; *Polycelis*, Ehrenberg; = *Prosthiostomum*, Quatrefages; *Tricelis*, Ehrenberg; *Planocera*, Mertens; *Leptoplana*, Ehrenberg; *Eurylepta*, Mertens;

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* On *Planaria Ehrenbergii*, in the "*Ann. des Wiener Museums*," for 1836, vol. i., p. 195. See also Oskar Schmidt's memoir "*Die Rhabdocœlen Strudelwurmer*," in the Vienna Academy's Transactions, 1858.

Proceros, Quatrefages; *Phagocata*, Leidy; ? *Diplanaria*, Darwin; *Polycladus*, Blanchard; *Tiphlolepta*, Oersted; *Centrostoma*, Diesing; *Prosticostoma*, Quatrefages; *Telostoma*, Oersted; *Cephalolepta*, Diesing; *Thysanozoon*, Grube; = *Eolidoceros*, Quatrefages; *Stylochus*, Ehrenberg; *Planocetra*, Oersted.

Rhabdocœlian group.—*Turbella*, Hemprich and Ehrenberg; = ? *Distigma*, Hemprich and Ehrenberg; = ? *Dalyellia*, Fleming; = *Amiba*, *Pupella*, and *Raphanella*, Bary; = *Proteus*, Müller; *Mesostoma*, Dugès (in part); = *Chonostoma*, Schmarda; *Planaria*, Fabricius; *Derostoma*, Oersted; *Catenula*, Dugès; *Strongylostoma*, Oersted; *Typhlomicrostoma*, Diesing; *Macrostoma*, Oersted; *Spiroclytus*, Schmidt; *Microstoma*, Oersted; *Dinophilus*, Schmidt; *Prostoma*, Oersted; = *Gyrator*, Ehrenberg; *Vortex*, Ehrenberg; ? *Prostoma*, Leidy; ? *Prostoma*, Dugès and Diesing; *Opistoma*, Schmidt; *Hypostoma*, Schmidt; *Anotocelis*, Diesing; *Stenostoma*, Schmidt; *Schizostoma*, Schmidt; *Typholana*, Ehrenberg; *Convoluta*, Oersted; *Monotus*, Diesing; = *Mesopharynx*, Schmarda; = *Monostoma*, Schultz; *Proporus*, Schmidt; *Diotis*, Schmarda; *Vorticeros*, Schmidt; *Plagiostoma*, Schmidt; *Spiroclytus*, Schmidt; *Trigonostoma*, Schmidt; *Orthostoma*, Schmidt; *Celidotis*, Diesing; = *Schizoprora*, Schmidt; *Nisus*, Schmidt; ? *Chloraima*, Kölliker; ? *Poseidon*, Girard; ? *Scotia*, Leuckart; *Catesthia*, Leidy; *Megastoma*, Schmarda; = *Telostoma*, Schmarda; *Acelis*, Diesing; = *Acmostoma*, Schmarda; *Octocelis*, Diesing; *Sidonia*, Schultze; ? *Goniocarena*, Schmarda; *Tricelis*, Quatrefages; *Allostoma*, Van Beneden; *Cylindrostoma*, Oersted; *Pseudostoma*, Schmidt; *Hypostoma*, Schmidt; *Tetracelis*, Hemprich and Ehrenberg; *Monops*, Diesing; *Anarthra*, Leuckart; = *Anortha*, Leidy; *Disorus*, Hemprich and Ehrenberg; *Stylacium*, Corda; *Aphanostoma*, Oersted; *Rhynchoprobolus*, Schmarda; = *Rhynchoscolex*, Leidy.

Nemertidæ.—This family of the Turbellarians, sometimes called ribbon-worms, is characterized by the presence of rounded, elongated bodies, possessing an uncommon degree of sensibility and extensibility. So remarkable is the power of extension, that one of the best known species (*Nemertes Borlasii*) is said to be capable of stretching itself to fully eight times the length of the body as it occurs in the ordinary state of rest; and in this case, therefore, the animal, which usually appears to be some five or six feet long, is capable of assuming, at any time, a length of at least forty or fifty feet. Professor Rymer Jones measured a specimen which was twenty-two feet when dead, and this worm, he felt certain, " might have been extended to four times the length" when alive, thus giving a total of no less than eighty-eight feet! Be this as it may, the Nemertidæ very closely resemble the common tapeworms—or Cestodes properly so called—not only by their band-like forms, but more particularly by their tendency to display transverse rugæ, which, as before remarked, acquire a certain degree of regularity. These animals, however, are furnished with a large protrusible proboscis and a simple digestive tube, the latter, according to some authorities, not terminating by any anal outlet. On the other hand, Delle Chiaje, Huschke, Rathkè, Oersted, and Von Siebold, consider that the intestinal canal opens by a distinct anus at the posterior extremity of the body. Dugès and Oersted describe a vascular system (in *Polystemma*) consisting of longitudinal vessels which anastomose in the region of the head; a similar arrangement being also observed by Quatrefages in *Nemertes mandilla*, where the vessels are three in number, two lateral and one median. Milne-Edwards states that the blood is colourless, but, according to Von Siebold, the Nemertians have red blood. This is a point which should not be left undecided by those who have opportunities of examining these worms in the living state. Rathkè and Quatrefages speak of the sexes as distinct, and the former has carefully described the nervous system as it occurs in *Borlasia*. He states that it consists of a pair of cephalic ganglia, which send off two long, lateral, non-ganglionic ventral cords, in addition to several small nerve-branches to the front of the head. Some of these are distributed to the eye-specks, which vary considerably in number in the different Nemertian genera; other special twigs being transmitted to the pits or depressions occurring on either side of the head which, moreover, have been described as "respiratory fossæ." The habits of the Nemertidæ have been amusingly descanted on by Dalyell, Montague, Rymer Jones, Gosse, and others, but we now stand in need of a careful reinvestigation of the anatomical peculiarities, development, and relations of the entire group.

Genera.—*Nemertes,* Cuvier; *Polia,* Delle-Chiaje; = *Baseodiscus,* Diesing; = *Borlasia,* Oken; = *Tæniosoma,* Stimpson; = *Valencinia,* Quatrefages; = *Quatrefagea,* Diesing; *Polyhopla,* Diesing; *Meckelia,* Leuckart; = *Notospermus,* Huschke; *Notogymnus,* Hemprich and Ehrenberg; *Ophiocephalus,* Quoy and Gaimard; *Colpocephalus,* Diesing; *Chlamydocephalus,* Diesing; *Astemma,* Oersted; *Polystemma,* Ehrenberg; *Hemicyclia,* Hemprich and Ehrenberg; *Ommatoplea,* Ehrenberg; *Amphiporus,* Ehrenberg; *Cephalothrix,* Oersted; *Emea,* Leidy; *Tetrastemma,* Ehrenberg; ? *Hecate,* Girard; *Serpentaria,* Goodsir; *Carinella,* Johnston; *Linneus,* Sowerby; ? *Lineus,* Beattie and Gray; *Cerebratulus,* Renier; *Micrura* (and larval *Pilidium*), Ehrenberg; *Acrostoma,* Grube; *Diplomma,* Stimpson; *Nareda,* Girard; *Oerstedia,* Quatrefages; *Tatsnoskia,* Stimpson; *Polina,* Stimpson; *Cosmocephala,* Stimpson; *Ramphogordius,* Rathkè; *Stimpsonia,* Girard; *Lobilabrum,* Blainville; *Prorynchus,* Schultze; *Tubulanus,* Renier; ? *Reneria,* Girard; ? *Siphonenteron,* Renier; *Leodes,* Girard; *Diplopleura,* Stimpson; *Cephalonema,* Stimpson; *Ditactorrhochma,* Diesing; *Loxarrhochma,* Schmarda; *Emplectonema,* Stimpson; ? *Dichilus,* Stimpson; ? *Lumbricaria,* Münster; ? *Nemertites,* Murchison; ? *Cololites,* Agassiz; ? *Medusites,* Germar.

In the briefest possible manner I have thus designedly sketched the typical and leading family characteristics of the Turbellaria, simply for the purpose of communicating a clear conception of the true position and affinities of this singular and comparatively little known class of worms. As before hinted, much remains to be accomplished in the way of our rightly understanding the visceral structure, genesis, and development of this diversely organized group; yet, on the other hand, sufficient appears to have been recorded in order to show that we are hardly warranted in separating these creatures from the sterelminthic entozoa, properly so called. Those who, with Von Siebold, prefer to retain the Turbellarians as a separate class, and who, at the same time, thrust the Nemertian division into the annelids proper, should, I conceive, in all fairness, not stop here, but cut away the Trematoda also, and make them an aberrant annelidan group by linking them and the Planarians on to the Annelida through the intervention of the closely allied Suctoria. At all events, with an equal show of reason, we might associate the Nematoda with the earthworms and other scolecine annelids; but I think it is now sufficiently well understood that any splitting of the Entozoa proper would only be attended with numerous disadvantages, not counterbalanced by those compensating features which ordinarily justify any radical change.

CHAPTER II.

TREMATODA.

The Trematoda, or flukes—Aspect and habits—Distribution in mammals, birds, reptiles, and fishes—Estimated number of species—Classification of the order—The family of Monostomes—Their development and genera—The Distomes—Their anatomical structure and development—Van Beneden's investigations respecting *Distoma militare*—Pagenstecher's researches—Genera.

In accordance with the plan proposed, I come now to speak of the second order of Helminths, which, under the old arrangement, would be the first order of the Entozoa proper. This order, the Trematoda, as the Greek word (τρηματώδης) from which it is derived indicates, is characterized by the possession of certain pores or openings; not that the presence of these pores, however, is altogether distinctive, but, when these characters are associated with other structural peculiarities, then their ordinal value becomes sufficient and, indeed, very strongly pronounced.

All the animals included in the order have soft, roundish, or flat bodies, their contained visceral organs being lodged in the general parenchyma of the body. This latter character, it will be remembered, we also found uniformly present in the other sterelminthic order, namely, the Turbellaria.

Aspect.—The ordinary aspect of these creatures is not such as would, at first sight, recommend them to the attention of the general observer; yet those who study them patiently will not fail to be struck by their beauty. They are small animals, usually visible to the naked eye, and seldom attaining any very significant bulk; a few of the minuter forms scarcely exceeding the 1-100th of an inch in length. The largest species vary from one to five inches in longitudinal diameter.*

Habits.—The Trematoda, or flukes, are not parasitic during the entire period of their existence, for while passing through the cycle of their life-development, they frequently change their residence, at times inhabiting either open waters or the dewy moisture of low pasture grounds. They perform active and passive migrations from parasitic to non-parasitic abodes; these phenomena becoming strikingly suggestive when we take into consideration the complicated series of facts which their various phases of development unfold. During their larval wanderings in search of a final resting-place which shall prove suitable to their adult condition, they provisionally occupy the bodies of different kinds of evertebrata; and, therefore, in order to complete the genetic cycle of the trematode-life, there must needs be a contemporaneity of both vertebrate and evertebrate types—a concurrence which, surely, no reasonable person can ascribe to mere fortuitous circumstances. These remarks are likewise more or less applicable to all the other helminths.

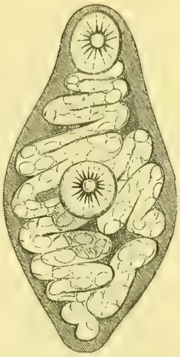

FIG. 1.—DISTOMA MINUTUM, *Cobbold.*—From the intestine of an oyster-catcher (*Hæmatopus ostrealegus*, L.) × 180 diam.—Original.

Distribution.—*In Mammals.*—Flukes are sparingly found in man and monkeys; they are still less frequent in the higher carnivora; none, to my knowledge, having been detected either in the lion or tiger. In the common cat two forms are known, one proper to the wild, and the other proper to the domesticated state. Only a few infest the dog and fox, and they are almost entirely absent in the civets and ichneumons, an exception occurring in the Indian Viverra. Flukes are abundant in the bats, being scarcely less prevalent in the moles and shrews, whilst three forms are known to infest the hedgehog. None have been described from the bears proper, but a species has been found in the closely allied badger. Weasels are particularly liable to invasion, and the same may be said of the amphibious seals. Rodents are tolerably free; but the *Fasciola hepatica* is said to have been found in the common squirrel. Rats and mice generally escape invasion, and none have been detected in the sloths; hares and rabbits, on the other hand, harbour these parasites. Flukes abound in swine, but seldom gain access to the horse or ass. Speaking generally, they are prevalent in all ruminating herbivores, being grievously numerous in sheep and cattle.

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* In making this statement I exclude Van Beneden's singular species *Nematobothrium filarina*, which, if accepted as a fluke, would give us a Trematode three feet and three inches in length. I have placed this genus in the Monostomidæ. For a description of the worm, see his *Mémoire sur les Vers Intestinaux*, p. 108.

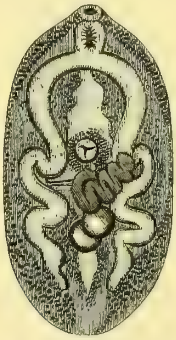

FIG. 2.—DISTOMA COMPACTUM, *Cobbold.*—From the lung of an Indian Ichneumon (*Viverra mungos*, L.) × 5 diam.—Original.

In Birds.—On the whole it may be said that the Trematoda are scarcely less abundant in birds than in mammals. Hitherto, so far as I am aware, they have not been met with in pigeons, parrots, or even in the insectivorous woodpeckers; but, as might be expected, they are of remarkably frequent occurrence in the alimentary canal of gulls, herons, storks, cranes, plovers, ducks, and other water birds.

In Reptiles and Fishes.—Trematodes are not uncommon in the cold-blooded reptiles generally, and they display considerable partiality for frogs and toads. In salamanders they occur less numerously, and in the saurian, chelonian, and ophidian orders they are comparatively unknown. In fishes the flukes are almost always present, being particularly plentiful in the stickleback, minnow, tench, perch, pope, bullhead, mackerel, trout, salmon, ling, burbot, turbot, flounder, lump-fish, sander, and dorado; they are still more abundant in the perch, pike, barbel, bream, eel, sole, sunfish, and sturgeon.

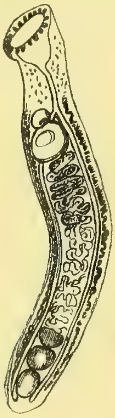

FIG. 3.—DISTOMA CORONARIUM, *Cobbold.*—From the alimentary canal of an Alligator (*Alligator Mississipiensis*, Cuv.) × 8 diam.—Original.

Number and Arrangement.—On the score of numbers no very accurate estimate can be formed. Not long ago I made a special investigation, partly with the view of determining this point, and communicated the results of this inquiry to the Linnean Society. In my "Synopsis of the Distomidæ," I recognized 344 species of flukes, 126 of these belonging to fishes, 47 to reptiles, 108 to birds, 58 to mammals, and 5 to the invertebrata. This list, however, did not embrace those leech-like forms of Trematoda (*Tristoma*, *Polystoma*, *Gyrodactylus*, etc.), many of which are ectozoa rather than entozoa in the ordinary sense of the terms. No doubt, on the other hand, many immature forms were described (from the older authors) as distinct species; yet, notwithstanding, when we take into consideration the additions which have been recently made—especially by Molin of Padua—and also the probably much larger number of forms which remain undiscovered, it becomes evident that at the very lowest possible estimate we may assume the order to comprise 400 species. These animals may be classed as follows:—

TREMATODA	*Monostomidæ* (Family I.)
	Distomidæ (Family II.)
	Tristomidæ (Family III.)
	Polystomidæ (Family IV.)
	Gyrodactylidæ (Family V.)

The arrangement here adopted is very similar to that offered in my "Synopsis," but I have since thought that the Monostomes, though essentially flukes, cannot consistently be placed under the Distomes—unless, indeed, we are prepared to abandon altogether this very simple and convenient mode of classification. The number of suckers (στωματα) forms a good, salient, family character, but in the case of the Polystomes a particular number need not be insisted on. Provisionally, at least, I prefer to let the group stand as above, where it will be seen that I have also elevated the Gyrodactyles into a distinct family.

Monostomidæ.—The members of this family are distinguished by the presence of a single pore or oral sucker, which is situated at the anterior extremity of the body. Usually the digestive system consists of two rather capacious cœcal tubes given off by the œsophagus and terminating on either side of the middle line, at the lower part of the body. In some species, however (*Monostoma mutabile* and *M. flavum*), the two alimentary tubes are blended together below in an arcuate manner. The sexes are always combined, the disposition of the reproductive organs closely resembling that found to obtain in the hermaphroditic Distomes. A well-marked excretory or water-vascular system exists, but no nervous elements have yet been described in any member of the family. There can be little doubt, however, that if carefully sought for, a pair of cephalic ganglia and two lateral cords will be discovered.

Development.—Most of the Monostomes reproduce oviparously in the ordinary manner, but in some instances the mode of reproduction is either ovo-viviparous, or altogether viviparous. This singular phenomenon occurs at least in one species (*Monostoma mutabile*), and its discovery by Von Siebold (in 1835) has tended to throw much light upon the genesis of flukes in general. Van Beneden and others have also ably followed up this subject, and have added many important particulars. The facts, as these authors have described them in the above-named species, may be briefly stated as follows :—Whilst still within the uterine tube the ova develop in their interior living embryos, which latter, at an early stage, display a pair of eye-specks, and, at the time of their exclusion from the egg-shell (chorion), have their bodies entirely clothed with vibratile cilia. At the same time, by a process of internal budding, the ciliated embryo has developed in its interior a larva, differing in form from the ciliated embryo (nurse or proscolex of Van Beneden) as much as the latter itself differs from the original parent. The ciliated animalcule (embryo) swimming freely, assumes for a time an independent existence, but after a while gives birth to the contained growing larva (scolex of Van Beneden), which latter itself becomes converted into a secondary nurse or sporocyst, developing in its interior several larval flukes in the condition of the well-known cercariæ. The actual conversion of the cercariæ into the sexually mature monostome, has not, so far as I am aware, been observed in any member of this particular family; but, from what we know of the final stages of the process as witnessed in the Distomata, there can be no doubt that these larval great-grandchildren, or cercariæ, ultimately become transformed into adult examples of *Monostoma mutabile.*

Genera.—*Monostoma*, Zeder; *Nematobothrium*, Van Beneden.

Distomidæ.—This family embraces the principal and best known genera of the order, and its members are at once recognized by the presence of two pores or suckers; one, the anterior, being connected with the mouth, the other, or the so-called *acetabulum*, being usually placed on the ventral surface, in the middle line. In some cases, as in *Amphistoma*, the acetabulum is situated at the posterior end of the body. In the arrangement of Van Beneden, the Distomes represent his digenetic section of the Trematoda, because in them (and in Monostomidæ) we have a double method of propagation—in other words, an alternation of generation—by eggs in the first instance, and by internal budding (agamogenesis) afterwards.

General structure.—It is a frequent habit with naturalists to select the common liver fluke (*Fasciola hepatica*) as a type of this family; but as this species deviates very markedly from all the other genera included in the family, and in respect of its digestive system approximates very closely to the Planaridæ, I purposely select some more simple and less known form to illustrate the general anatomy of the family under consideration; at the same time reserving the common fluke for minuter anatomical details in the second part of this work.

The small fluke here selected is the *Distoma conjunctum*, numerous examples of which I discovered (1858) in the liver of the American red fox (*Canis fulvus*). A group of them are represented of the natural size (plate ii. fig. 1). Fig. 2 is an enlarged view of one of these parasites, showing its pyriform outline and smooth integumentary surface (x 35 diam.). At the anterior extremity is a round oral sucker (*a*), the *acetabulum* being placed at the lower part of the upper third division of the body (*b*). The mouth, properly so called, is placed at the base of the cephalic sucker, and leads into a small, oval, muscular œsophageal bulb (*c*), the latter directly communicating with two long, cylindrical, digestive canals (*d*, *d*); these widen out a little as they approach

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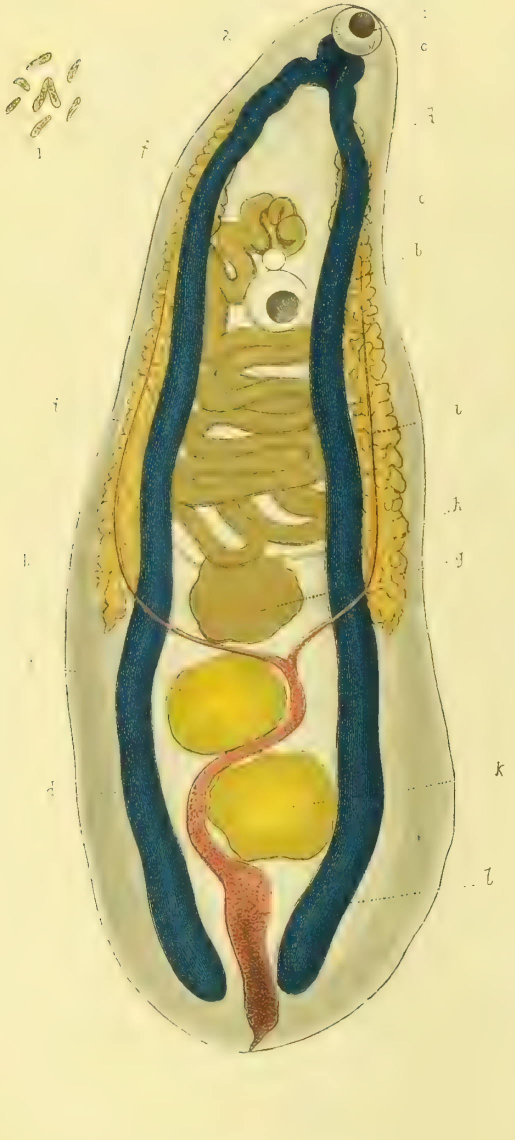

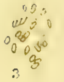

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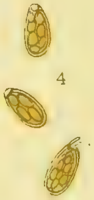

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the caudal extremity, where they terminate in rounded cœcal ends. Immediately above, and in contact with the ventral sucker, there is situated a small, circular papilla (*e*) which usually exhibits two minute openings on its surface; these being, respectively, the outlets of the male and female reproductive organs. One of the openings in question communicates with a set of wide, tortuous tubes (*f*) occupying the centre of the upper half of the body. This uterine tube is usually of a deep yellow-brown colour — a natural appearance due to the presence of multitudes of small ova crowded together in the interior of the convolutions. Below this greatly elongated uterus, there is an irregularly oval mass situated directly in the mesial line; this is the ovary (*g*), and from it two narrow tubes may be seen passing off, one towards either side of the body. The two ducts in question are connected with the two botryoidal masses (*i*, *i*), or yelk-forming glands, which are apparently situated between the alimentary tubes and the lateral borders. Further down, below the ovary, and in the central line, are the two testes (*k*, *k*), the ducts of which—as seen in an allied species here represented in a woodcut (fig. 4)—pass upward in an undulating line towards the reproductive papilla. Lastly, there is the true excretory, or water-vascular system, here represented by two straight (artificially-coloured) red tubes (*h*, *h*) lying immediately in front of the yelk-forming glands, and, at the lower part, curving downwards and inwards, so as to coalesce in the central line, where they combine to form a broad sigmoidal duct. In this situation the vessel lies between the two testes, below which it suddenly increases in width, forming what is called the *contractile vesicle* (*l*). Throughout its entire course this system of vessels contains a fluid in which is suspended a multitude of highly refracting granular particles; these latter, when they escape by the minute aperture placed at the base of the contractile vesicle, constantly display the well-known phenomena of molecular motion. A separate mass of these glittering particles are shown (at fig. 5). In regard to the ova (figs.

3 and 4), all that need here be said is that they usually present an oval figure, having a yellow-brown chorion, a more or less segmented yelk, and a transverse line near one pole of the shell which serves to indicate the point at which their lid-like extremity becomes detached after the subsequent maturation of the embryo. One of the eggs represented in the plate has been artificially ruptured in this situation. I may also mention the circumstance that I have found (as shown in the centre of fig. 1) two of the flukes sexually combined—a fact of great significance in relation to the probably erroneous notion entertained by some, that the hermaphroditic flukes are capable of self-impregnation.

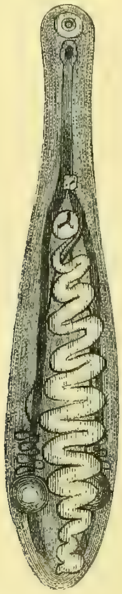

FIG. 4.—DISTOMA BOSCII, *Cobbold.*—From the oral cavity of an American snake (*Coluber*). × 10 diam.—Original.

Development.—Ever since Steenstrup's discovery that the cercariæ found in the bodies of water snails were only larval flukes, a peculiar interest has attached itself to this subject; for not only were the facts which he elicited novel in themselves, but they formed a basis for the enunciation of that interesting "law of alternate generation" with which the great Danish naturalist's name will ever be imperishably associated.* In all essential particulars Steenstrup's statements and facts have been verified, whilst, at the same time, such a multitude and variety of data bearing upon this question have since been placed on record, that it is utterly impossible—consistent with the design of the present work—to discuss the subject at any very great length. I can do no more than select one good example to illustrate the phases of development, through which certain of the distomes pass; adding, however, Dr. Pagenstecher's general conclusions respecting those modifications of structure and habit found to occur in certain larval types.

The species selected for illustration is the *Distoma militare* of Rudolphi, a form which I have elsewhere arranged under Dujardin's sub-genus *Echinostoma* ("Synopsis," Linn. Proceed., vol. v., Zool. Div. p. 34), but which I shall now, to prevent confusion, call a true distome. The entire cycle of the life-development of this species has been successfully investigated by Van Beneden, from whose researches I gather most of the following facts; many of which have, notwithstanding, been also more or less clearly determined by Pagenstecher, Steenstrup, Von Siebold, and others.

In the adult, or sexually mature condition, the *Distoma militare* produces a limited number of oval-shaped eggs (fig. 5 *a*) which, after the usual process of yelk-segmentation, give birth to an oval, free swimming, and finely ciliated embryo (*b*), the latter subsequently developing in its interior an oblong organism called a sporocyst (*Scolex*, Van Beneden). All the distomes commence life in this manner, but Van Beneden is not absolutely certain that the ciliated embryos here drawn from his figures (*b* and *c*) were produced by the ova of the particular distome now employed for illustration. This is, however, a matter of trifling consequence, as the process is essentially the same in all the flukes, and he succeeded in tracing the rest of the stages without interruption. Thus the sporocyst, at the time of its first separation from the ciliated embryo, presents a very simple appearance (*d*), showing a sort of head and body, the latter containing a digestive tube or cœcum in its interior. There is also a slight fissuration of the caudal end, indicating the first rudiments of two appendages, which, in a more advanced condition of the sporocyst, look like a pair of imperfectly fashioned limbs. These lobed appendages are also present in the sporocystic condition of the *Monostoma mutabile* previously alluded to, as well as in other trematode larvæ. In the next stage here indicated (fig. 6 e) we have a well-developed head (*a*) and body (*b*), the tail (*c*) becoming pointed and strongly pronounced. The limb-like lobes (*d*) project on either side at the lower part of the body, and an oval sucker (*e*) makes its appearance in front. This communicates by a short passage with the œsophageal bulb (*f*), and passes directly into the single digestive cœcum or stomach (*g*), which contains a variable number of rounded particles, supposed to be the food. At this stage, also, one or more incompletely developed cercariæ (*i*) may be seen in the

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* I entirely coincide with Dr. Carpenter in regarding the expression "alternate generation" as calculated to mislead. The term "generation" should only be applied to the products of sexual congress, and not to the non-sexual progeny in common with it. It would certainly be more correct to speak of the "law of alternate gemmation" or agamogenesis.—T. S. C.

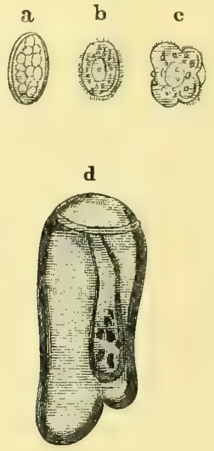

Fig. 5.—Egg (*a*), embryos (*b*, *c*), and sporocyst (*d*), (Distoma militare, *Rudolphi*).—Van Beneden.

perivisceral cavity, soon to be followed by many others in company. These cercariæ are, at first, shapeless, irregularly elongated bodies, but after passing through a series of gradations they ultimately assume a well-marked definite form, which, in many cases, is sufficiently distinctive to enable us to refer them to a particular species of *Distoma.* The older writers, overlooking the fact of their being only larvæ, described many of them as adult flukes. In their early cercarial state, these larvæ invariably exhibit more or less conspicuously-developed tails, as may be seen in the accompanying drawing (fig. 6 f), where a number of them are included in the cavity of the body of a sporocyst still further advanced in development. Here they are seen twisted and folded in various attitudes, presenting, moreover, not only a cephalic and ventral sucker (*acetabulum*), but also a dark forked line within—the latter constituting the first appearance of the digestive system in accordance with the true distome type. At a still further stage, and after their escape from the sporocyst, other structures come into view until we get that well-known and perfected condition

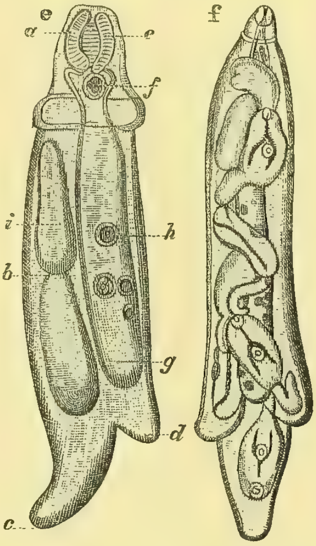

FIG. 6.—Sporocysts of *Distoma militare* (*Scolices*, Van Ben.) in a more advanced condition; the one (e) showing an early condition of the agamic progeny which in the other (f) has developed into tailed *cercariæ.*—Van Beneden.

of the cercaria, which is faithfully represented below (fig. 7). Here, therefore, we have an oral sucker (*a*), a pharyngeal bulb (*b*), an œsophagus (*c*), two alimentary cœca (*d*, *d*), a ventral sucker (*e*), a water-vascular system consisting of two excretory (urinary, Van Beneden) ducts (*g*, *g*), and a contractile vesicle (*f*) by means of which the ducts communicate with the external surface. The tail (*h*) is largely developed, and characterized by a highly distinctive marginal fringe (*i*, *i*), which has not, apparently, been found in any other form of cercaria. Be that as it may, this free-swimming tailed cercaria strictly conforms in its alimentary structure to the general Trematode type, but before it passes into the sexually mature condition it has other changes to undergo. These are brought about, in the first place, by their parting with their tails, and subsequently by their encysting themselves usually on or within the surface of the body of some mollusk or aquatic insect. This constitutes their pupa condition as shown in the annexed illustration (fig. 8) where the pupa is represented in the act of escaping from the cyst. The pupa itself differs from the

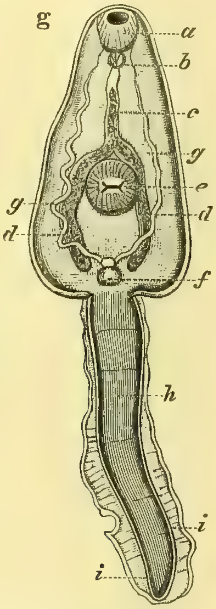

Fig. 7.—Fully developed cercaria of *Distoma militare*. × 300 diam.—Van Beneden.

cercaria in presenting a double crown of hooks surrounding the head, but several of the organs (marked *b*, *c*, *e*, and *g*) will be seen to correspond with those displayed in fig. 7. According to Van Beneden the cephalic hooks commence to make their appearance immediately after the larva encysts itself. In this condition the larva next becomes transferred to the intestine of some higher animal, and in this situation it gradually acquires all those organs, the possession of which will entitle it to be called a sexually mature or adult distome. Soon after its passive immigration to the final host, traces of the reproductive organs make their appearance; certain portions of the parenchyma being set aside, as it were, or differentiated so as to form the matrices of these complicated organs. These phenomena may be clearly understood by an examination of Van Beneden's representation (fig. 9, p. 28), in which the following parts are readily discernible:—Commencing from above, we have the mouth (*a*), the buccal or cephalic sucker (*b*), the pharyngeal bulb (*c*), the œsophagus (*d*), the digestive cœca (*e*, *e*), the coronal spines (*f*), the contractile vesicle (*g*), the aquiferous system of vessels (*h*), the matrices of the yelk-forming glands (*i*, *i*), and also a central mass of cellules (*k*, *l*), from which all the other reproductive organs will in due time be developed. In the adult condition (*Distoma militare*) the head is abruptly truncate in front, the posterior extremity pointed and narrow, and the upper third of

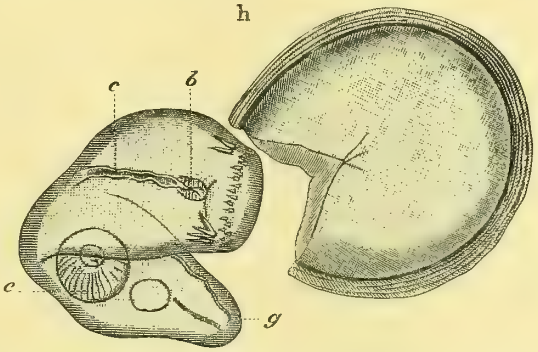

FIG. 8.—The Pupa, or tail-less Cercaria (Proglottis, Van Ben.) escaping from its ruptured cyst.—Van Beneden.

the body clothed with little spines; its general aspect being altogether very different from that presented by the highest of the phases of development here illustrated.

The above description may be regarded as offering a fair illustration of the mode of development ordinarily taking place in the Trematode parasites, at least, in that (digenetic) division in which we find a double mode of propagation. It does not convey, however, an accurate conception of the various changes which, under certain peculiar conditions, the larvæ appear to be capable of undergoing; for it would seem, from Pagenstecher's researches, that their multiplication and degree of organization are liable to vary considerably, according to the altering conditions of season and weather. On these and many other points connected with the history of the development of the trematoda, Dr. Pagenstecher's statements are so extremely interesting that I do not hesitate to

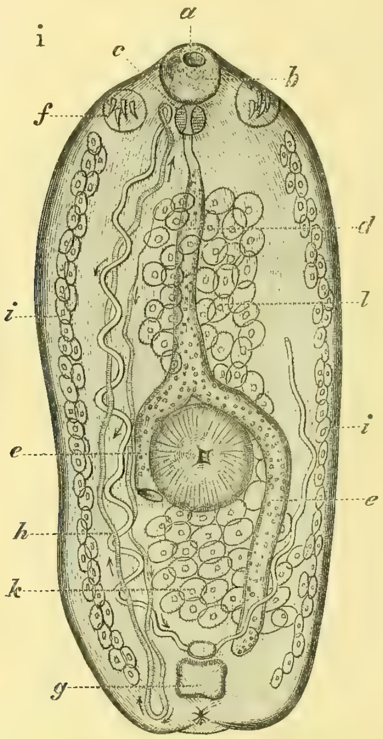

FIG. 9.—The young or sexually immature *Distoma militare* —Van Beneden.

append the results of his inquiries, as recorded in the *Schlussbemerkungen* of his admirably illustrated memoir.*

" (*a*).—The eggs of the trematoda vary in respect of size, form, and colour, being either furnished or not with a lid, and accordingly distinguishable. In the mature condition they contain a ciliated or a non-ciliated embryo of unequal growth, this embryo partly increasing in size, even after its birth. In various conceivable ways, the eggs themselves, or the embryos which have quitted their shells, arrive in and upon the bodies of mollusks, where they are consequently found. In this situation the egg opens, or the ciliated covering decays, and the contained motionless germ—which in itself offers no distinctive characters—having become free, grows into a nurse, or forms several nurses within itself.

" (*b*).—Whilst some of the trematodes display a highly organized nurse-condition, others exhibit only a simple kind of germ-sac. Both forms, nevertheless, appear to occur in one and the same species, depending, in all likelihood, upon external causes.

" (*c*).—The organized nurses (or *rediæ*, as they are termed) have a mouth and a strongly marked muscular œsophagus, which is continued into a short or prolonged, single, blind intestine; or the latter may be double. The expulsion of animals developed within them I have only seen to take place through an opening at the hinder extremity. Old rediæ loose their structure. I did not observe any vascular system. Tailed trematode larvæ (*cercariæ*) as well as rediæ themselves, are developed within the rediæ, this variation of nurse-contents probably depending on the season.

" (*d*).—No independent new germ-sacs are developed within the simple unorganized germ-sacs (sporocysts), and only such trematode larvæ as are capable of arriving at sexual maturity are furnished with special appendages.

" (*e*).—When the immature contents of both nurse-forms (*i. e.*, of sporocysts and rediæ) are accidentally set free, and are situated within the organs of nutrition of the living host, then they appear prepared to develope themselves anew into nurse-forms; and, moreover, cercariæ whose development has not yet attained a definite stage—and even their tails also—appear to enjoy a similar capacity. Some nurses are likewise capable of multiplication by division and budding.

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* Trematodenlarven und Trematoden. Von H. A. Pagenstecher, M.D., Heidelberg, 1857.

"(*f.*)—Some germ-sacs have the property of developing within themselves cercaria-like larvæ—which are different from the true cercariæ—from whose body the development of a *distoma* may take place, while their single or double tail-like appendages in all cases develop anew into germ-sacs. To this class belong *Bucephalus* and *Distoma duplicatum*.

"(*g.*)—All the cercaria at present known are destitute of eyes, but other forms of trematode larvæ are furnished with visual organs. Accordingly, I never found eyes in young distomata whilst they were in their last dwelling-place, but eyes are certainly present in the young forms of *Polystoma* and *Amphistoma*. The supposition that a spontaneous wandering is associated with eyes is not yet confirmed in my experience.

"(*h.*)—As a means of distinguishing the different forms of cercariæ, among other indications, their places of dwelling may be useful, because each mollusk only harbours a limited number of species. Notwithstanding, Professor Filippi is in error if he believes that every species of mollusk carries only a single armed form of cercaria. A migration of the cercaria is indispensable to its perfection.

"(*i.*)—Many larval trematodes form cysts round themselves, probably by means of a special organ of secretion, and also by the epidermis. Their future destiny necessitates this. The sporocysts apparently fulfil towards the larvæ which are developed within them a similar purpose, namely, a protection against the stomachal digestion of the new host. In the pupa condition the development of the larva, which has now thrown off the tail, makes greater or less progress, according as to whether it is surrounded by nourishment or not. In particular, while in this stage, the different kinds of hooks for migration purposes, make their appearance, always, without doubt, after the shedding of the skin. Other trematodes pass through this tail-less sexually immature stage without any cyst. I have not yet seen any larval-trematode forms which had been produced in sporocysts or rediæ without appendages; they appear to occur, nevertheless.

"(*k.*)—As the larvæ exist only in a few hosts—and most of them dwell only in one species of animal—so, also, the continued progress towards sexual maturity only succeeds in the case of certain well-defined larval organisms; but the digestion of the cysts and liberation of the larvæ may be accomplished in various animals.

"(*l.*)—The armed cercariæ appear to be larvæ of the spine-covered distomes of amphibia; for, as examples, the *Cercaria ornata* becomes transformed into *Distoma clavigerum*, and *C. armata* into *Distoma endolobum;* the *Dist. duplicatum* and *Cerc. diplocotylea* are, apparently, the juvenile forms of *Dist. cygnoides* and *Amphistoma subclavatum.* The *Dist. echiniferum* of *Paludina* could neither be advanced in development in the frog or duck, nor could all the other larvæ which I subjected to experiment be developed either in the green or brown frogs.

"(*m.*)—When young trematodes arrive at the right place for their maturation, then the male generative structures develop before the female organs, and in the subsequent excess of egg production the form and structure of the animal becomes obliterated. A copulatory act is not described as certain, but some speak of such an arrangement, while others are in favour of the view of self-impregnation.*

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* I beg to call Dr. Pagenstecher's attention to the fact, that I have observed an actual sexual congress in the case of *Distoma conjunctum.* This was first recorded in my third paper, published in the "Linnean Transactions," vol. xxiii. p. 350, and I have elsewhere alluded to the circumstance, as well as in the present work (p. 22). I do not believe any one has ever witnessed a process of self-impregnation in the trematode entozoa or in their allies. Notwithstanding Leuckart's representations respecting *Tænia echinococcus,* I am not certain that this process is ordinarily accomplished in the Cestoda.

T. S. C.

"(*n.*)—The yelk molecules surrounding the germinal vesicle are not directly transformed into an embryo. On the contrary, they only appear to part with a portion of their constituent elements, which portion, in combination with the germ vesicle, and by means of the latter, is employed in forming the embryonic cells, whilst the other portion remains superfluous. Again, in regard to the vascular system of trematoda, it is partly ciliated and partly non-ciliated; but, at all events, we find that the vessels have a wall furnished with a lining of epithelium. There is little doubt that the circulating fluid enters from without; however, its principal function is excretory. In some species, or in some parts of the system, the excretory matters do not render the circulating fluid turbid; at other times it appears that they are mixed with much solid matter which becomes excreted through the caudal opening."

Genera.—*Fasciola,* Linneus; *Campula,* Cobbold; *Distoma,* Zeder; *Dicrocœlium,* Dujardin, Weinland; *Bilharzia,* Cobbold; = *Gynæcophorus,* Diesing; = *Thecosoma,* Moquin-Tandon; = *Schistosoma,* Weinland; *Köllikeria,* Cobbold; *Crossodera,* Dujardin; *Echinostoma,* Dujardin; *Gasterostoma,* Von Siebold; *Wedlia,* Cobbold; *Codonocephalus,* Diesing; *Eustemma,* Diesing; *Holostoma,* Nitzsch; *Hemistoma,* Diesing; *Diplostoma,* Nordmann; *Rhopalophorus,* Diesing; *Amphistoma,* Zeder; *Amphiptyches,* Grube and Wagener; *Tylodelphys,* Diesing.

CHAPTER III.

PARTICULAR TYPES.

Structure of particular trematode types—Fasciola—Gasterostoma—Campula—Bilharzia—Echinostoma—Family of the Tristomes—Their development and Genera—The Polystomes—Genera—The Gyrodactyles—Wedl's researches respecting their organization—Development—Von Siebold's and Van Beneden's opinions contrasted.

UNDER this head I first proceed to offer a few remarks respecting one or two of the more striking or otherwise interesting forms belonging to the last-described family of Trematodes. These descriptions and notices must necessarily be brief.

Fasciola.—As I have elsewhere urged, the common liver fluke ought not to be placed under the genus *Distoma*, its proper generic title being *Fasciola*, as first proposed by the illustrious Linneus (1767), and subsequently adopted by F. Müller (1787), Brera (1811), Ramdohr (1814), and others. Unfortunately, Retzius (1786) and Zeder (1800) changed the generic appellation without good cause, and the majority of writers, following their authority, refuse to employ the original name, notwithstanding that the distinctive types of structure displayed by the two genera, respectively, demand the retention of the Linnean title. A glance at the arrangement of the digestive apparatus, as shown in a fasciole I discovered in the Giraffe (1854), exhibits a marked deviation of the simple distome type (see Frontispiece). I have now publicly, for several years past, and at regular intervals (1854-56-58-60-62), strongly urged a final adoption of the Linnean nomenclature, the propriety of this view having been previously advocated by Blanchard. I think it would even be preferable to abandon the genus *Distoma* altogether (substituting *Dicrocœlium*, as Weinland has done) than to place the fascioles under any other title than that indicated by Linneus.

Campula.—The propriety of the view above advanced is rendered more cogent by the discovery of an intermediate type of fluke, whose digestive cœca, instead of displaying the dendritic character of the Fascioles, offer a peculiar zigzag-like form; hence the generic title (καμπύλος). In April, 1855, I procured about fifty specimens of this trematode (Fig. 10) from the liver of a common porpoise (*Delphinus phocœna*). They occupied the peripheral extremities of the biliary ducts, which were, in the situations occupied by the flukes, remarkably thickened and knotted. As many as seventeen individuals were found associated at one spot.

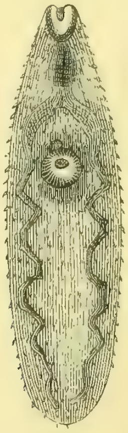


Fig. 10.—Campula oblonga, *Cobbold*; from the liver of the Porpoise. × 15 diam.—Original.

Bilharzia.—Up to the time of Bilharz's announcement of the existence of the *Distoma hæmatobium*, which he found so abundant in the people dwelling on the borders of the Nile, almost all the flukes were considered to be hermaphroditic, or, in other words, each individual was furnished with both male and female organs; the only exception being that of the *Distoma fillicolle*, regarded by Rudolphi and Dujardin as a species of *Monostoma*. Guided by this fact and by the circumstance of other co-existing peculiarities, I formed a distinct genus for the reception of the Egyptian fluke, employing for this purpose the original discoverer's name. Since this was done I have observed that several foreign helminthologists have acted in a similar manner, but, as usually happens in such cases, they have employed different generic titles, so that the nomenclature has become rather complicated. However, letting this pass, the genus *Bilharzia,* in itself so peculiar, is only yet known to infest man and monkey. Here, it must be admitted, is an interesting circumstance, admirably suited to the taste of those who are on the look-out for affinities of habit between bimana and quadrumana. The *Cercopithecus fuliginosus* is an African monkey, and, doubtless, in its native haunts it procures the larvæ of its *Bilharzia* from the same sources as our brethren in Egypt. Up to the present time we are uninformed as to the habitat and characteristics of its larval state, but Griesinger conjectures that the young exist in the waters of the Nile, in the fishes which therein

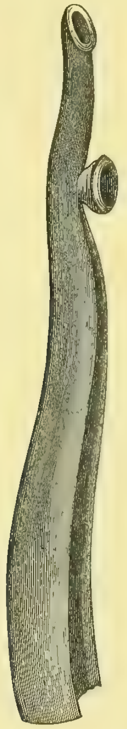


FIG. 11.—Upper third of BILHARZIA HŒMATOBIA, *Cobbold;* from the portal vein of an African Monkey (*Cercopithecus fuliginosus*). × 10 diam.—Original.

abound, or even in bread, grain, and fruit. It is more probable, however, that the larvæ will be found in gasteropod mollusks proper to the localities from whence the adult flukes have been obtained.

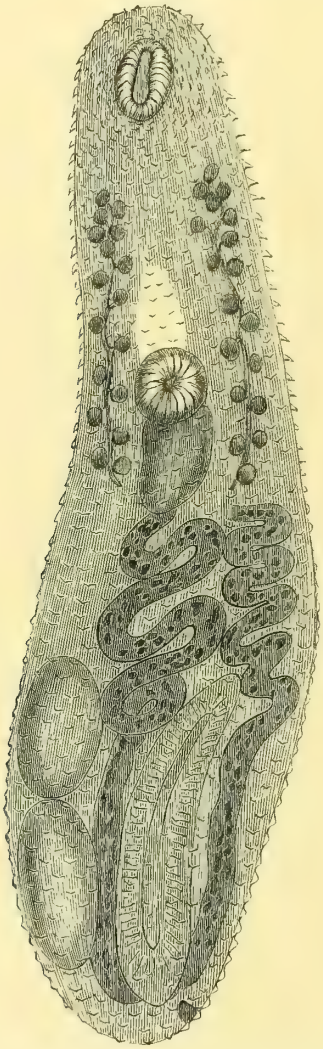
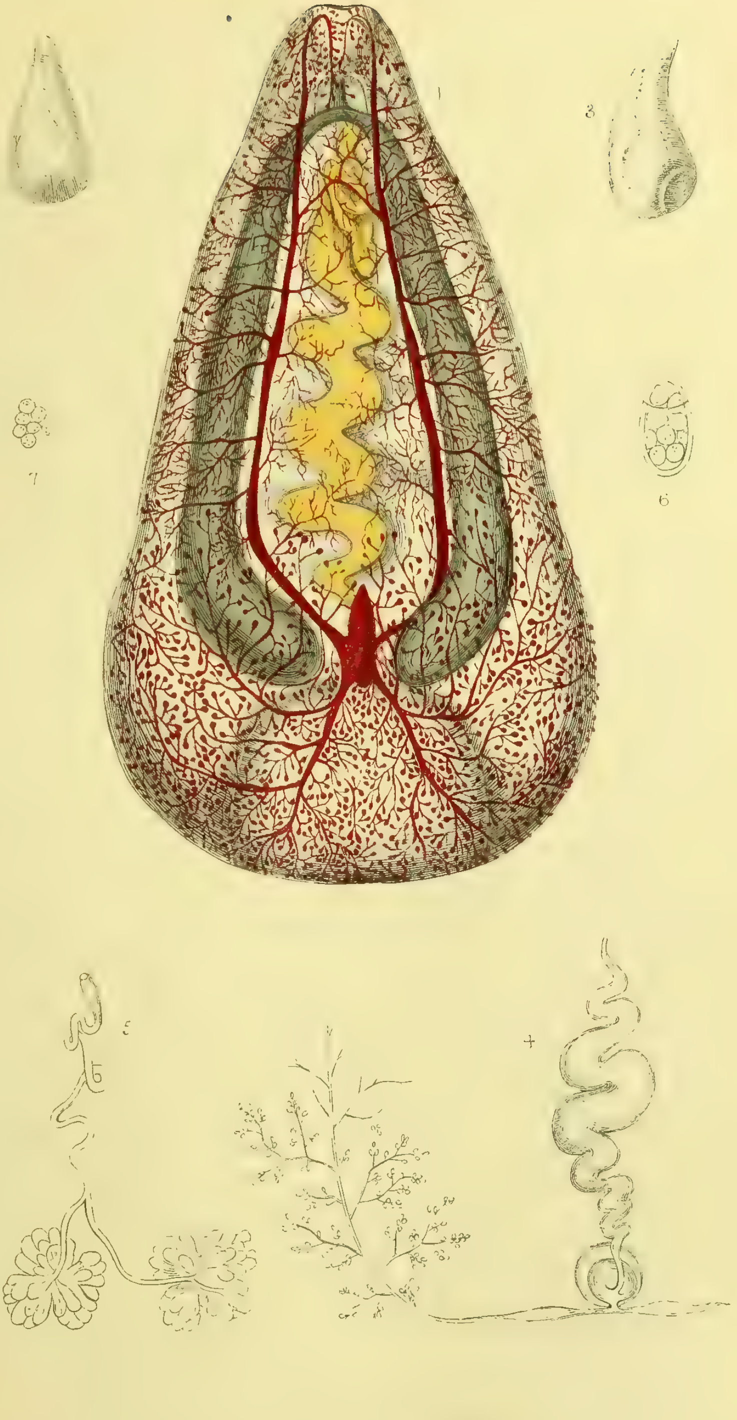


FIG. 12.—GASTEROSTOMA GRACILESCENS, *Wagener;* from the intestines of the Angler (*Lophius piscatorius*). × 60 diam.—Original.

Gasterostoma.—In this singular genus the ventral sucker (Fig. 12) seems to have taken the position usually assigned to the oral opening, whilst the latter is placed low down towards the centre of the body. The digestive cœca also disappear, leaving only a short stomachal cavity, which reminds one of the same viscus in the imperfectly organized sporocysts or rediæ. The yelk-forming glands exhibit conspicuous, round, secreting cells, the testes being also largely developed. I have also noticed two other small bodies, one of which probably represents the ovary or germstock, whilst the other may be referred to the *receptaculum seminis*, or posterior seminal vesicle of Von Siebold. The connection between these several organs is not seen in this specimen, but their relative position is well shown. When the species first came under my observation, I naturally followed Rudolphi, who described this trematode as a distome (*D. gracilescens*, Rudolphi). I remember seeking most diligently for the digestive tubes, being greatly puzzled, not merely by their absence, but also by the character and position of an organ which we now well know to be the sheath of the intromittent appendage. The uterus also terminates in its immediate vicinity, opening externally by a common outlet. The anatomy of this genus has been pretty fully illustrated by Von Siebold. According to Molin, the excretory, water-vascular organ (or respiratory apparatus, as he interrogatively puts it) consists (in *Gasterostoma fimbriatum*) of a broad central tube occupying the entire length of the body. In connection with this tube, he did not discover any branches, but he represents it as a simple sac opening externally at the caudal extremity.

Amphistoma.—The most marked character in this genus has reference to what may be styled the caudal position of the acetabulum, which is also very largely developed, being two or three times greater than the oral sucker. This feature is admirably shown in the copy here given of Blanchard's enlarged figure of *Amphistoma conicum* (Plate III. Fig. 1), the same species being also represented by two other views where it is drawn twice the natural size (Figs. 2 and 3). The digestive system conforms closely to the true distome type, as do also the reproductive organs, both of the male (Fig. 5) and female (Fig. 4). The ova in this species are about 1-150th of an inch long, and 1-250th of an inch in breadth. The egg represented in the accompanying plate (Fig. 6) was obtained from an amphistome found in the paunch of a Zebu formerly living in the London Zoological Society's Menagerie. Fig. 7 represents a group of sperm-cells or corpuscles from the testes. The latter organs, according to my own dissections, are not oval, but lobed, and, therefore, I have in this particular modified the otherwise generally accurate representation of Blanchard. But the most striking appearances in the accompanying illustration have reference to the pouched cœcal ends of the minute twigs of the water-vascular system, which, if Blanchard's drawings are correct, entitle him to the credit of having first pointed out such a mode of origin in these vessels. Dr. Guido Wagener has indicated a similar arrangement in connection with the water-vascular system in *Holostomata*, but my own recent inquiries enable me to assert most positively that no such enlargement of the ultimate ramifications obtains in the genus *Fasciola*. The general arrangement of these vessels in the last-named genus is indicated in one of the figures given in the Frontispiece, but I reserve a more particular account of this system until I specially treat of the anatomy of the common fluke in the Second Part of this work. In the meantime I would call attention to the differences observable in the arrangement of the vessels of *Fasciola* as compared with the same series of structures in *Amphistoma*. Long ago, Laurer pointed out the course pursued by the two main channels, from the head downwards on either side of the body, and their ultimate communication by means of a pyriform reservoir, as here shown on the dorsal surface of the Amphistome. Several authors, such as Bojanus, Diesing, Laurer, and Blanchard, have described a nervous system in this genus, and Laurer even affirmed that he had seen ganglionic enlargements along the course of the principal nerve-trunks both here and in other trematodes. It is very doubtful, however, if any lateral ganglia exist. The larvæ of *Amphistoma conicum* have not yet been identified, but in all likelihood they dwell in the bodies of water-snails. This may be inferred from the circum-



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After Blanchard.

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stance that the larvæ or cercariæ of another species (*Amphistoma subclavatum*) which, in the adult condition, dwells in frogs and newts, have been found both by Filippi of Turin and Pagenstecher of Heidelberg, on the surface of the body of various species of *Planorbis;* it would seem also, that Van Beneden has found them in different species of *Cyclas.* If this be correct, it becomes quite clear that when deer, sheep, or cattle resort to ponds and running streams to quench their thirst, they necessarily run the risk of infecting themselves with these larvæ; and in this way they are probably transferred to the paunch or rumen, where, becoming attached to the internal lining membrane of the organ, they complete their final stage of development.

Echinostoma.—In this genus—or sub-genus, as originally established by Dujardin—the oral sucker is surrounded by a circle of little spines, or it occupies the centre of a disk which is cleft at the ventral or anterior aspect. In the latter case the disk is either bordered both laterally and above by spines, or there are two large, lobed appendages, whose margins are furnished with spines. In other respects this genus very nearly corresponds with the typical distomes, but the simple digestive tube bifurcates immediately below the œsophageal bulb. As an illustration, I select the *Echinostoma hispidum,* which species Dujardin—being misled by Creplin's erroneous description—omitted to place in this genus, although he had previously entertained a very strong suspicion that it was a true echinostome. The specimen here drawn (Fig. 13) was taken by me from the spiral intestine of a sturgeon (1855), in which fish it occurs very abundantly. It will be noticed that there are two rows of large spines surrounding the cephalic disk, the latter structure being incomplete at the ventral margin (which is here turned away from the observer). The relative disparity of the two rows of cephalic spines are better seen in more highly magnified figures of these organs. The integumentary spines clothing the general surface of the body vary considerably in character, according to their position. Those situated at the neck are narrow and sharply pointed, but, as regards size, they gradually dwindle down to a mere point or tubercle as our inspection approaches the caudal extremity, where, in point of fact, they become altogether obsolete. In the enlarged figure here given, we obtain a back view of the head and a lateral view of the body, the neck having been partially twisted; the ventral sucker is concealed, but the semi-transparency of the skin permits a view

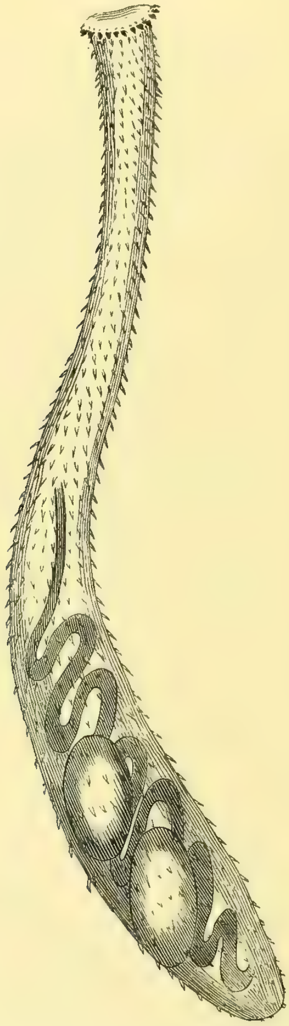

FIG. 13.—ECHINOSTOMA HISPIDUM, *Cobbold;* from the spiral intestine of the Sturgeon (*Acipenser sturio*). × 15 diam.—Original.

of the internal reproductive organs, which it is here unnecessary to particularize.

Tristomidæ.—The various members of this family display a leech-like aspect, in consequence of which they have been placed either along with the *Malacobdellidæ*, or in some other allied family of the suctorial annelids. It is admitted, on all hands, that the tristomes are not entozoa in the literal acceptation of the term, yet it will be seen that their internal organization conforms more strictly to the trematode type than to that of the *Hirudinidæ.* Thus, they support two small suckers anteriorly and one large sucker posteriorly, the body being externally smooth, devoid of annulations, and more or less compressed. The mouth is placed in front between the cephalic suckers, communicating with a beautifully ramified and dendriform intestine, whilst the main divisions of the latter, from either side, combine at the lower part of the body, so as to form a closed system of tubes. The tristomes have therefore no anus. In some species the large caudal sucker is sessile; in others it is stalked or pedunculated, being in either case bordered by a membranous fold (Dujardin). All the species are hermaphroditic, and display an arrangement of the reproductive organs very similar to that which we find to be present in the flukes, properly so called. These animals, as before implied, are ectozoa, some of them living on the gills of fishes, others attaching themselves to the general surface of the bodies of their piscine hosts, selecting especially the neighbourhood of the fins, whilst a third kind are parasitic on crustaceous parasites, the latter being also attached to marine fishes.

Development.—Our knowledge of the genetic history, in so far as it relates to the typical members of this family, must be considered very imperfect; but in the case of the aberrant genus *Udonella*, the mode of development is known to be remarkably simple and direct. In this genus, according to the researches of Van Beneden, the embryos are comparatively large, and they acquire the form and characteristics of their parents whilst they are still within the egg-shell. Even before the period of their liberation, they exhibit all the essential organs of reproduction and alimentation, and are therefore ready to assume an independent existence the moment they quit the shell. The eggs themselves are oval, with a slight tendency to become pyriform, being a little compressed laterally at one pole, where the chorion is prolonged into a single filamentary process, which may be aptly termed the "holdfast." Van Beneden suggestively compares a group of them to a "bouquet of vorticells." On quitting the shell the embryonic *Udonella* at once attaches itself to the *Caligus*, and in this situation continues to grow until it acquires the adult condition. The entire course of development is thus rendered extremely simple, and we are hereby confronted with the fact of a trematode worm passing through its life-cycle without the remotest indication of those phenomena of alternate generation which so commonly prevail amongst the true distomes, monostomes, and other digenetic flukes.

Genera.—Tristoma, Cuvier; = *Nitzschia*, Von Baer; = *Capsala*, Bosc; = *Phylline*, Oken; *Epibdella*, Blainville; *Udonella*, Johnston; = *Amphibothrium*, Frey and Leuckart; *Encotyllabe*, Diesing; *Calicotyle*, Diesing; *Benedenia*, Diesing; *Notocotyle*, Diesing.

Polystomidæ.—This family comprises a variety of remarkable genera characterized by their possessing in common several suckers which, for the most part, border the posterior extremity of the body; but, in respect of form and general appearance, they are often widely dissimilar. I accept the family as an equivalent to Dujardin's first group of trematodes which he termed "*Onchobothriens*," rejecting only his genus *Diporpa*, since we all know from Von Siebold's researches that this form is a juvenile condition of *Diplozoon*. In this family Van Beneden includes the genera *Calceostoma* and *Gyrodactylus*, but I propose to place these singular organisms in a separate family. In all the Polystomes we have a more or less ramified intestine, but the reproductive organs conform to the general trematode type, exhibiting only certain departures in their mode of arrangement. All are hermaphroditic, the eggs being supplied with filamentary appendages, in some only at one pole of the shell, in others at both ends. The water-vascular system is conspicuously developed. All the species are supplied with an armature of prehensile hooks, these horny structures being either connected with their complicated series of suckers, or else placed altogether independently apart, in which case they are usually situated in the central line of the body. In the sexually immature Diporpa-condition of the genus *Diplozoon*, there are two supernumerary hooks associated with a dorsal sucker at the centre of the body, and it is by means of these anomalously-placed organs that a conjugation between two such juvenile forms is effected. These two individuals become organically united for life, after the fashion of the Siamese twins ; and, according to the investigations of Von Siebold, it is not until after this conjugation has been consummated that the sexual organs make their appearance. In *Onchotyle appendiculata* we are presented with peculiarities of form scarcely less remarkable. In this creature the lower end of the body suddenly merges into a curious appendage which is placed almost at a right angle with the body itself, and in this way, as Van Beneden justly remarks, the entire animal resembles a little hammer; the resemblance being very much heightened by the circumstance that one end of the appendage is cleft so as to correspond, as it were, with the notch which we employ in the action of nail-drawing. At the bifurcate extremity of this singular tail Van Beneden describes the occurrence of two oval contractile vesicles. These organs open separately, one at either point, being also internally connected with the water-vascular system, which is consequently double in this genus. In point of function, Van Beneden regards these vessels as uriniferous. A little above the pulsatile vesicles we find two recurved hooks, which are likewise bifurcate at their base, and there are other prehensile elements occurring in connection with these suckers. Each one of these last-named organs, of which there are six in all, supports a single scimitar-shaped horny piece designed to strengthen the sucking and grasping action of the disk; and the latter organ consists of a strong, muscular, spherical cup, whose margins are capable of being folded somewhat after the fashion of a double nightcap. As regards the visceral arrangements of this genus, it is unnecessary to enter into minute details, but I may briefly remark that the digestive cœca are rather irregularly ramose, whilst, in other respects, these organs conform to the general trematode type. The species here described was, in the first instance, discovered by Kuhn attached to the gills of a dog-fish (*Scillium catulus*), but it has since been found as an ectoparasite upon other marine fishes. Its ova carry two filamentary "holdfasts," one at either extremity of the chorion.

Genera.—Polystoma, Rudolphi; = *Hexacotyle,* De la Roche; = *Plagiopeltis,* Diesing; = *Hexabothrium,* Nordmann; *Plectanophorus,* Diesing; = *Plectanocotyle,* Diesing; *Diclibothrium,* Leuckart; = *Hexacotyle,* Nordmann; = *Diplobothrium,* Leuckart; *Solenocotyle,* Diesing; *Octobothrium,* Leuckart; = *Placoplectanum,* Diesing; = *Octostoma,* Kuhn; = *Octoplectanum,* Diesing; = *Mazocraes,* Hermann; = *Octocotyle,* Diesing; = *Diclidophora,* Diesing; = *Cyclocotyle,* Schultze; = *Discocotyle,* Leuckart; *Axine,* Abildgaard; = *Heteracanthus,* Diesing; *Onchotyle,* Diesing; *Diplozoon,* Nordmann; = *Diporpa,* Dujardin; *Grubea,* Diesing; = *Pleurocotylus,* Gervais and Van Beneden; *Cotylaspis,* Leidy; *Aspidocotyle,* Diesing; *Aspidogaster,* Von Baer.

Gyrodactylidæ.—As a fifth family of Trematoda, I here bring together those singular ectoparasitic creatures known as the Gyrodactyles, along with an apparently closely allied genus to which Van Beneden has applied the title *Calceostoma.* The Gyrodactyli have hitherto been classed with the Polystomidæ, but one would think that the absence of *several* suckers would be alone sufficient to justify a separation. Amongst the characters which stand out most prominently are those having reference to the presence of peculiar hooks projecting from the posteriorly-situated sucking disk. In the aberrant genus *Calceostoma*, this mechanism is reduced to a single, though complex, horny structure placed at the margin of the caudal sucker in the central line, but in some of the Gyrodactyli, the hooks are particularly numerous. As an intermediate type, I may instance *Gyrodactylus elegans*, where the caudal sucker supports a pair of large laterally-recurved hooks, which are placed back to back in the centre of the disk, being connected at their upper or basal ends by the supervention of a transversely disposed median, semilunar portion. A series of tentacles serve to increase the prehensile action of the sucker. In many species

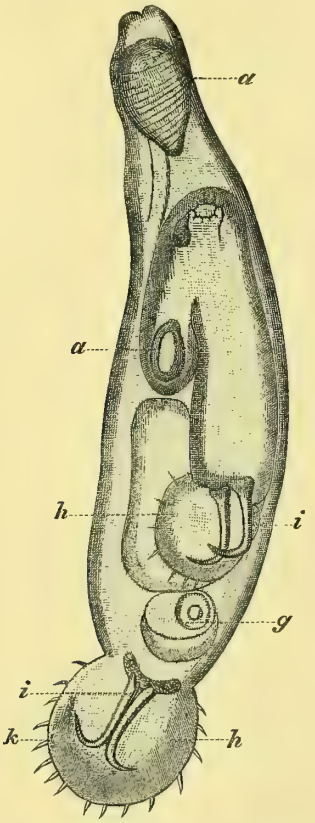

FIG. 14.—GYRODACTYLUS ELEGANS, *Nordmann;* from the gills of *Cyprinus brama*, showing an almost completely developed embryo in the interior; *a*, *a*—œsophageal bulb; *g*—testis; *h*, *h*—posterior sucker; *i*, *i*—the two large hooks; *k*, *k*—the little marginal spines of the sucker. Highly magnified.—Van Beneden.

there are accessory horny developments in connexion with the male reproductive apparatus.

The general organization of Gyrodactylus has been fully elucidated by Continental writers, and more especially by the independent investigations of Nordmann, Siebold, Guido Wagener, Van Beneden, and Wedl, from whose combined experience we have, at length, arrived at the most satisfactory results. As Wedl's conclusions are summarized within a small compass, I shall here, instead of offering minute details of any one particular type, subscribe his final account of the principal characters of this group:*—

a. "*Gyrodactylus* is found on the gills of fresh-water fishes under numerous specific forms, *G. elegans* being also found by Creplin and Siebold on the fins. Moreover, as I have found nearly every species of fish supporting a particular gryodactyle-representative, it would seem that each finny creature supplies its own *Gyrodactylus*. Sometimes two of them are parasitic upon the same gill, being frequently associated with *Trichodinæ*, as well as with the still unintelligible *Psorospermiæ*."

b. "The clasping apparatus at the posterior end of the body must—in an animal so soft and constantly exposed to the passage of regular currents — be comparatively strongly developed and accommodated to the peculiar dwelling-places; and probably the varying character of the latter supplies a reason why there should be so great a difference in the mechanism of the hooks belonging to the disk.

c. "The hooked apparatus affords a very valuable and mathematically precise means of diagnosis in the determination of species. This differentiation may be accomplished by observing whether there are two or four large hooks; whether there be one or two connecting portions, and by noticing their several forms and relations to one another; and whether, again, there are hooklets or not, remarking in the first instance their position, form, distribution, and so forth.

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* Wedl, Prof. Dr. K.—Anatomische Beobachtungen ueber Trematoden, s. 34, et seq., Wien, 1857.

d. "The integument is sometimes wrinkled transversely, at other times appearing to be smooth.

e. "The muscular apparatus is, in certain cases, very strongly developed. In the majority of instances special muscles are inserted into the handles of the hooks, and they are also very frequently directed into the transverse muscles of the skin. In *Gyrodactylus crassiusculus*, we find a *protrusor penis* and *retractor palparum medius*.

f. "Except in the case of *G. elegans*, four so-called eye spots are observed at the anterior extremity of all Gyrodactyli. As Siebold says, they answer the purpose of light-refracting organs. The palpi—which in *G. crassiusculus* are seen to contain muscular bundles—appear to be retractile touch-organs, extending more or less prominently forward.

g. "Observations in regard to the alimentary canal are at present incomplete, for only in the case of *Gyrodactylus cochlea* did I find a single gullet demonstrable. This was furnished with epithelium, being tinged either yellow or brownish yellow. It passed from before backwards, and was probably furnished with an anus, whilst, in all other instances, its passage could not be traced. The reason of this arises from the transparency of the intestinal contents, and from the internal blending of the wall of the canals with the parenchymatous substance. The other organs also hinder our observation.

h. "In three species of *Gyrodactylus*, namely, in *G. cochlea*, *G. crassiusculus*, and *G. tenuis*, the generative organs are thus disposed:—The vitelline organ is characterised by its botryoidal structure, and its round secretion-cells containing granular matter. These organs are so completely enveloped by a limiting membrane that there is no direct connexion between them and the oral sucker. The excretory duct lies in front of the ovary. In all the Gyrodactyli, where, generally speaking, one egg with its yellow shell came under my observation, there was only this solitary example to be seen, and I only observed its escape on one occasion. The two seminal vesicles, standing out most conspicuously in *G. tenuis*, are filled by a convolution of filaments, and intercommunicate by a canal. The connexion of the posterior seminal vesicle with the presumed testes was not perceptible; but the anterior is in continuity with the external, horny, male reproductive apparatus. The last-named organ is characterized by much variety of form, so that one may exclaim, '*Ex pene speciem.*' Speaking generally, we observe a peculiar, more or less curved penis, grooved for the passage of semen, and an accessory solid portion which is often hooked. The latter serves, probably, as a fang or organ for adhering to the vagina. In one instance where the accessory portion was absent, I found two hooklets at the entrance of the vagina. These, in all probability (functionally), represented the same, (being formed) for the purpose of laying hold of the penis when the latter was lodged within the sheath. Thus *Gyrodactylus* becomes sexually developed, and cannot be regarded merely as a kind of 'nurse.'"

Development.—The genetic relations subsisting amongst the Gyrodactyles are in some respects peculiar, and have given rise to much controversy. We have abundant records of the principal facts and phenomena observed in the reproductive process, and, for the most part, there is little contrariety of opinion in regard to such data; but, unfortunately, the method of interpreting these phenomena has, according to the source whence it has proceeded, produced a very variable result. Von Siebold, observing the singular mode of reproduction as it takes place in *Gyrodactylus elegans*, arrived at the conclusion that Gyrodactyles in general were only nurse-forms of some higher organism, and he pointed out, with undeniable accuracy, all the birth-stages of the young one as it apparently pullulated within the parent and subsequently emerged an almost perfect Gyrodactyle. Von Siebold also remarked that the so-called "daughter," at the time of birth, nearly equalled the "parent" in respect of size; whilst, moreover, it contained within its interior another very young Gyrodactyle, or, in other words, a "grand-daughter." Professor Van Beneden, as we shall presently see, interpreted these facts very differently, but, it must also be noted that Von Siebold's ideas had gained a very general acceptance. For my own part, I incline to the views of Van Beneden; but provisionally accepting Von Siebold's conclusions—so far, at least, as *G. elegans* is concerned—I may proceed to remark that I also have noticed the second generation, or daughter, to contain in its interior evidences of what I, at the time, supposed to be a third generation.* This phenomenon I observed in specimens of the worm obtained from the tails of Gasterostei caught in the Serpentine, Regent's Park. Indications of the third progeny were seen whilst the daughter still resided within the body of the nurse-parent, but the so-called grand-daughter acquired much greater conspicuity immediately after birth. In one instance, I had a very satisfactory opportunity of watching the process of separation. The "daughter" commenced showing itself externally by a slight bulging at the centre of the body of the parent, whilst the integument of the latter yielded on all sides of the bud-like projection, and in such a manner as to convey the idea of a vaginal opening, although a sheath of this kind was by no means actually visible. There was an evident struggle on the part of the young one to free itself from the so-called parental envelope, but the tissues exhibited no evidence of injury. On partial protrusion, it was seen that the budding portion corresponded with the centre of the daughter's body, and this, in a little while, assumed the aspect of a semi-circular, or horseshoe-shaped, band. Subsequently the upper or anterior end became detached, the freed extremity being now recognized as the head, characterized by the possession of two ventricose lobes. A considerable interval elapsed before the broad posterior end of the animal could be disengaged, but immediately after this was effected the sides of the parental envelope closed in upon the opening, and all that remained was a small cavity or sac, indicating the position recently occupied by the "daughter" *Gyrodactylus.* Altogether, the process occupied about five minutes from the commencement of the "budding" to the closure of the assumed vaginal outlet. In this instance I carefully compared the so-called "parent" with the "daughter," but in regard to size I can scarcely aver that the former was the larger of the two. The similarity of bulk is, perhaps, more apparent than real, owing to the circumstance that the freed young one rapidly extends itself and moves about in all directions, whilst the parent as readily contracts, or "shuts up," so to speak, thus appearing at a striking disadvantage.

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* As stated in my paper on *Gyrodactylus* in the "Microscopical Journal," new series, vol. ii., p. 36, 1862.—T. S. C.

As I have before hinted, Van Beneden demurs altogether to the relational view of these creatures established by Von Siebold. He does not admit the parent to be a kind of "nurse;" he does not consider the primary young one to be a "daughter;" and, consequently, he does not regard the embryo seen within the latter as a "grand-daughter." Van Beneden, whose words I translate literally, writes as follows:*—"According to our researches there is here a false interpretation; the little daughter is lodged within the side of its pretended mother, and not in its interior; instead of being its mother, it is its sister; there is a difference of shape, because there is a difference of age; the Gyrodactyles are viviparous, and as among the higher Trematodes the eggs are formed one by one, one embryo is scarcely formed when another commences its evolution, and the egg-deposition is effected even whilst the embryo is being produced. The Gyrodactyles are therefore viviparous worms which beget a single embryo at a time, as those of the trematode group to which they are allied beget a single egg at a time; and before the first embryo is expelled another is already partly developed. There, we believe, lies the correct interpretation of that phenomenon; instead of a bud it is an embryo, which has escaped from an egg. Here, therefore, we have no phenomenon of alternate generation or of digenesis, as Von Siebold supposes, but a simple viviparous reproduction."

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* "Mémoire sur les Vers Intestineaux."—Paris, 1858, p. 65.

Genera.—*Gyrodactylus*, Nordmann; *Dactylogyrus*, Diesing; *Calceostoma*, Van Beneden; *Tetraonchus*, Diesing; *Diplectanum*, Diesing.

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CHAPTER IV.

NEMATODA.

The order of round worms, or Nematoda—Aspect, habits, and distribution—Probable number of known species—Classification—Anguillulidæ—The common vinegar eel as a type—Genera—Gordiidæ, or family of hair-worms—Dujardin's account of the structure of *Mermis nigrescens*—The views of Meissner, Von Siebold, and Van Beneden respecting the development of Mermis—Genera—Structure of Sphærularia—Oxyuridæ, or thread-worms—Organization of *Oxyuris curvula*—Genera.

In the foregoing chapters I have devoted as much space as could be spared for a general description of the sterelminthic group of worms; and, therefore, I now pass to the consideration of the third order of helminths, or, in other words, to the Nematoda. This order is, as we have seen, equivalent to the second sub-class or cœlelminths, in which the internal organs are loosely suspended within a well defined perivisceral cavity. The term Nematoda (νημα-εῖδος) implies the possession of a more or less thread-like form of body, but, in conformity with the most obvious and general character presented by nearly every member of the group, these helminths are with greater frequency denominated *round worms*. So far as I am aware, all the forms (except that of a new genus—*Simondsia*, T. S. C.) are very much longer than they are broad, and it is only in a few exceptional cases that we find a tendency towards the flattened character seen in other helminthic types.

Aspect.—The Nematodes as a whole, and especially the more typical and better known forms, bear a marked external resemblance to the common earthworm; but their internal organization, when compared with that of the latter, will be found to differ most materially. The majority of the species are of small size, varying usually from a few lines to two or three inches in length; however, there are some exceptionally large individuals whose longitudinal admeasurement extends to several feet. Cogent examples of this kind may be instanced in the great, red-coloured, kidney-worm *(Eustrongylus gigas)*, in the large round-worm of the horse *(Ascaris megalocephala)*, and in the guinea-worm *(Dracunculus medinensis)* of tropical countries.

Habits.—Most of the Nematoda are parasitic only during a portion of their life-time, though it must be allowed, as a rule, that the period of their non-parasitic existence is comparatively limited. Some few are altogether non-parasitic. In the case of those round-worms which expel their ova in a very imperfectly developed condition, a long immersion of the eggs in water appears to be necessary for the development of the embryo. In such cases the time of their non-parasitic condition will vary from six to twelve months, or even more. After this period, if they are not soon passively transferred to their proper hosts, they will, in all likelihood, rapidly perish. Even in the case of the armed embryos of *Mermis*, the continuance of life is probably dependant on the success which attends their efforts to bore their way into the bodies of the hosts—grubs and caterpillars—which are suitable to them. In the Nematodes, therefore, larval migration is necessary for the welfare and continuation of the species, and this "wandering," as it is called, may be accomplished either in an active or in a passive manner.

Distribution.—Nematodes infest abundantly the human body; they are scarcely less numerous in the higher apes and monkeys, being also tolerably frequent in the bats. Almost always present in the carnivora, we find them especially common in cats, dogs, and weasels. No less than six species, referable to four distinct genera, are described as infesting the hedgehog, not a few also occurring in the allied moles and shrews. In rats, mice, squirrels, rabbits, hares, and other rodents, they are equally abundant. Some few species have been found in the edentates, but they are much more prevalent in swine and their allies. In herbivorous animals, generally, they are common, being remarkably numerous in the horse, ass, ox, deer, and sheep. One or two species are constantly present in the seal and porpoise respectively, but we are very imperfectly informed as to their presence or absence in the large cetacea. The Nematodes, as a group, are particularly liable to invade all kinds of birds, especially game and poultry. In reptiles they are certainly less numerous; but in fishes they are almost as prevalent as in the feathered tribe. On the whole, therefore, it may be affirmed that, in so far as reference is made to the vertebrate host, the nematode species are more generally, numerously, and uniformly distributed than the individual members of other helminthic orders.

Number and Arrangement.—It is more difficult to arrive at an approximatively true estimate of the total number of nematode species in existence, than it is to form a similar estimate in regard to the other kinds of helminths. This arises first from the circumstance that the forms are undoubtedly more numerous and more widely distributed; secondly, because a multitude of juvenile forms have been taken for adults; and thirdly, because the reputedly distinct forms are less markedly definable than are those belonging to other orders of parasites. Altogether, nearly 800 species have been either described or indicated, but at the very lowest estimate I should think that not less than 250 of these so-called species might be legitimately cast aside as spurious. This very necessary deletion permits us to assume that the order of Nematodes, as at present known, comprises about 550 species. The various forms, naturally grouped, may be classed in the following manner:—

NEMATODA.
- *Anguillulidæ* (Family I.)
- *Gordiidæ* (Family II.)
- *Oxyuridæ* (Family III.)
- *Filaridæ* (Family IV.)
- *Cheiracanthidæ* (Family V.)
- *Ascaridæ* (Family VI.)
- *Strongylidæ* (Family VII.)
- *Cucullanidæ* (Family VIII.)

Anguillulidæ.—Here may be conveniently brought together a vast number of minute thread-worms, whose intimate organization and course of development is not yet well understood, but whose general anatomy is so far known that we need have little hesitation in placing them along with the other nematode families. Some of the obscurer genera may turn out to be annelids, and a more correct classification will thus be ultimately adopted. A considerable number of the Anguillulidæ are non-parasitic, at least, so far as animals are concerned; a few are believed to be so altogether. Some of the species are found in moist earth, in sour paste, in vinegar, and in various vegetable matters undergoing acetous fermentation; while others occur endo-parasitically in earthworms, in aquatic mollusks, in the larvæ of beetles and other insects, in the alimentary canal of batrachians, and also in the digestive system of fishes. Some are oviparous, others viviparous. Nearly all appear to possess a remarkable tenacity of life, and in certain species this phenomenon is truly astonishing. Thus, in *Anguillula fluviatilis,* the body may become entirely dried by exposure to the sun's rays, but the animal will revive immediately after moistening by a shower of rain. In like manner, many of the species may be frozen without destruction to their life; but, on the other hand, some of the forms will bear neither the extremes of heat nor cold; in a few instances, it is said that the application of a moderate heat will prove fatal. In the case of *Anguillula tritici,* where the life-tenacity is most strongly marked, the observations of Trembley, Needham, Bauer, Dujardin, and others, have shown that the animal is capable of revivification after complete desiccation extending over a period of four or even five years.

Selecting the common vinegar eel *(A. aceti)* as a type, we have a filiform body about forty times longer than it is broad, and seldom attaining one-twelfth of an inch in length. Some are said to have measured one quarter of an inch from head to tail, but it is most common to find them about half a line, or in the case of the females, from one to two or more milimètres long. The front of the body is narrowed, terminating in a slightly abrupt truncate point, the mouth being central, simple, and unarmed. The pharynx is prolonged backwards into a strong, spherical, muscular, œsophageal bulb; the latter being succeeded by a long, cylindrical, intestinal tube which ends in a distinct anal opening, placed a little above or at the basal portion of the tail. Some regard the œsophageal bulb as the stomach, and all recognize, within it, a special dental apparatus. The tail is conical and finely acuminate, that of the male being supplied with two intromittent spicules of equal length. In the female, which produces its young viviparously, the vaginal outlet is situated a little beyond the posterior third of the body. As in other Nematodes, the uterus early divides into two oviducal tubes, in the interior of which the young embryos may be seen either free or still enclosed within their egg-shells.

Genera.—*Anguillula*, Ehrenberg; =*Rhabditis*, Dujardin; = (in part) *Vibrio*, Müller;=*Enchelidium*, Ehrenberg; *Pontonema*, Leidy; *Enoplus*, Dujardin; *Urobales*, Carter; *Amblyura*, Hemprich and Ehrenberg; = *Enchelis*, Hill, *Oncholaimus*, Dujardin; ? *Odontobius*, Roussel; *Diplogaster*, M. Schultze; ? *Dorylaimus*, Dujardin; ? *Phanoglene*, Nordmann; *Dicelis*, Dujardin; ? *Phacelura*, Hemprich and Ehrenberg; *Leptodera*, Dujardin; *Pontonema*, Diesing; *Isacis*, Lespes; ? *Nema*, Leidy; ? *Hemipsilus*, Quatrefages; ? *Potamonema*, Leidy.

Gordiidæ.—The filiform, thread-like hair-worms are for the most part characterised by the possession of an extremely elongated body, which is usually supplied with a mouth and intestinal canal, the latter ending cœcally instead of opening by an anus. In *Gordius aquaticus* there is a mouth and œsophagus but no intestine, a similar rudimentary condition of the digestive apparatus being also found in *Mermis nigrescens*. In *Anguillina monolis*—which I take to be identical with the *Filaria rigida* infesting different species of *Aphodius*—the intestine is, according to Siebold, altogether wanting, and the same may be said of *Sphærularia bombi*. In the young of *Dracunculus*, as recently shown by Mr. Bastian, the alimentary canal terminates by a cœcum near the middle of the body, and not, as Robin and myself had supposed, by an anal outlet. In other anatomical arrangements the various species of Gordiidæ vary still more strikingly, especially as regards the disposition of the reproductive organs. In all, however, the sexes are distinct, and they are parasitic during a portion of their life-time, the greater number taking up their temporary residence within insects, whose bodies they penetrate from without. In the same manner the female of the Guinea-worm, or *Dracunculus medinensis*, gains access to the sub-integumentary tissues of the human body; but it does not apparently seek to imitate the Gordii proper by voluntarily quitting the host at a comparatively early stage of its life-period. The Gordii, after their escape, deposit multitudes of ova in long agglutinated chains either in water or moist situations; the Dracunculi, on the other hand, reproduce viviparously, the young being discharged whilst the parent is still lodged within its host. All the Gordiidæ, like their anguilluline congeners, are remarkably tenacious of life, and both in the young and adult conditions, will endure complete desiccation for a lengthened period without injury to their vital powers.

Reserving my account of the general anatomy and development of Dracunculus for the second part of this work, I purposely select the genus Mermis as a type of the family under consideration. In Gordius the integument is smooth externally, presenting, when highly magnified, a beautifully reticulate arrangement of the epithelium, but in Mermis the skin near the head is furnished with a variable number of papillary eminences which are probably homologous with the more numerous wart-like eminences so characteristic of the singular genus Sphærularia. In the year 1842, Dujardin ably investigated the anatomy of *Mermis nigrescens*.* He describes the integument as being composed of three distinct layers; first, an external homogeneous epidermis, which is readily separated by dissection; secondly, a double layer of perfectly smooth and continuous fibres which cross one another obliquely so as to form a double system of spirally rolled bands, encircling the body from end to end; and thirdly, a dense internal cartilaginoid stratum, consisting of from fifteen to thirty extremely fine laminæ. According to Mr. Bastian (who has minutely examined the integument of Dracunculus) the spiral appearances are of a spurious character, being due to a certain play of the transmitted light when the structures are viewed under the microscope; and I have myself seen similar double spiral diffraction bands when examining the little cysts of *Trichina spiralis.* Dujardin, however, further states that in the region of the head—which in *M. nigrescens* supports five or six papillæ—these fibres wind themselves round the papillæ in a regular manner, but near to the caudal extremity they form a number of irregular gyrations. Below, or in connection with these papillæ, "the integument presents a lacuna or conical cavity in communication with the great space surrounding the œsophagus," and Dujardin thus conceives that these openings are for the passage of water into the space in question. This periœsophageal space is said to be distinct from the general visceral cavity of the body, being continued, according to Dujardin, into the two longitudinal *cordons sarcodiques,* which pass from head to tail distributing to either side during their course numerous transverse branches at tolerably regular intervals. Some of the branches bifurcate into secondary twigs. Besides these *cordons sarcodiques,* it is added, that if the integument be viewed from within, we observe two longitudinal undulating lines or ridges—*crêtes ou cordons saillans*—destined to establish a communication with the muscular layer or *tube charnu.* These appearances evidently correspond with the very similar structures to be seen in most of the nematodes, and therefore, in the opinion of the writer of this work, these structures severally represent rudimentary conditions of the nervous and water-vascular systems. Dujardin, however, expresses himself at variance with this view, as will be seen by the passage quoted below.[*] The muscular layer consists of longitudinal and radiating fibres intimately blended together, forming a *tube charnu*, which is lined internally by a soft parenchymatous mass, common to Nematodes generally. In this mass Dujardin recognized another canal, which he regarded as a secreting organ concerned in the production of certain peculiar bodies termed oviferous capsules; but in forming this opinion he was doubtless in error. At all events, the interior of the canal is described by him as being lined by "a large ovarian band or longitudinal placenta;" and to this band numerous oviferous spherical capsules are connected by means of a double row of funiculi. Each capsule contains within it a single ovum, which, when mature, makes its escape by the natural separation of the two halves or valves of the capsule. At the time of embryonic maturation the funiculi or chalazæ become detached from the longitudinal band, their free ends splitting up, as it were, into numerous filaments or brush-like processes. These structures which, in some respects, may be regarded as unique, have been since described by Meissner, Van Beneden, etc., and have been shown by them to be normally developed within the ovarian tube; the last-named authority did not observe any of them to be connected to the rachis or longitudinal placenta described by Dujardin.

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* Annales des Sciences Naturelles; 2e série, tome xviii., p. 129.

Development.—In regard to the antecedent and other changes connected with the history of the development of the ovum, it has been pointed out by Meissner that in *Mermis albicans* the first reproductive changes consist in the formation of germ cells within the narrow cœcal extremity of the ovarian tube. This, of course, is the first essential step of the process in all the Nematoda; but important differences of detail are found to characterise ovular

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[†] "Ces cordons en raison de leur inégalité ne me semblent nullement pouvoir être assimilés à des vaisseaux ou à des nerfs; s'il fallait faire quelque conjecture sur leur nature et sur leur röle physiologique, j'aimerais mieux supposer qu'ils servent à l'accomplissement d'une sorte de respiration branchiale, exécutée dans l'interieur de la cavité et à la face interne du tégument, comme cela a lieu chez les Systolides et chez les Naïs."

production, not only in distinct genera but even in species—at least, this appears to be the case, if the facts recorded by authorities are trustworthy. In the situation referred to, the first formed germ-cells display two or more nuclei within, and these rapidly multiply as development advances. By and by the nuclei enlarge and project from the parent germs, ultimately forming semi-independent secondary germs, or, more correctly, unimpregnated primitive ova. The original parent germ now becomes a bond of union between the quickly enlarging primitive ova, constituting, in fact, the *rachis* of Dujardin. Each primitive ovum now acquires a more or less pyriform shape, being connected to the rachis by a narrow peduncle, and one entire group of such ova assumes the aspect of a botryoidal cluster, or so-called egg-raceme. At a further stage, when the primitive ova are ready for impregnation, they separate, according to Meissner, from the rachis, and the fractured surface of the ovum where it joined the pedicle becomes the micropyle aperture. This opening is supposed by Meissner to give admission to the spermatozoa of the male, and the consequent admixture of the latter with the yolk granules of the primitive ova constitutes the very act of impregnation. After this act the germinal vesicle of the primitive ovum disappears, and the process of yolk segmentation soon commences, which, of course, speedily determines the formation of the embryo.

As before hinted, the details of this process in *Mermis* are somewhat peculiar, and they differ remarkably from what has been observed by Nelson, Thomson, and others, in *Ascaris*, and by Lubbock in the more closely allied genus Sphærularia. In this place, however, I must leave the consideration of the mode of egg-development, in so far as it concerns the genus *Mermis*, and reserve my necessarily brief notice of the controverted points as regards the egg-development of other Nematodes for separate treatment. Meanwhile, I have to remark, that at or near the time of the maturation of the ova of Mermis, the parent worm, hitherto lodged within the body of some insect, seeks to bury itself in the soil, and it accomplishes this wandering by boring its way out of the body of the host. Some discrepancy of opinion exists as to the actual condition of the parent at the time of its wandering, for Von Siebold asserted, that it quitted its parasitical mode of life " in order to become sexually mature away from the animal" infested; whereas, Van Beneden states, that the embryos are always formed at the time of the wandering. From Siebold's interesting experiments it would appear that incompletely developed Mermes, accidentally or otherwise separated from their hosts, and placed in moist earth, are capable of becoming sexually mature, whilst still in the soil; but in all probability the normal condition requires the wandering to commence, as before remarked, at or near the time of full embryonic development. In any case the embryos are viviparously reproduced, and being set free they pass a certain time of their early life in the earth. Here they grow rapidly, and acquire sexual organs, subsequently seeking, as Von Siebold happily expresses it, to "gratify their immigrative propensities," by selecting and penetrating into the soft-bodied larvæ of lepidopterous and other insects. This entrance they are enabled to accomplish by means of a sharply-pointed dentule or boring stylet, which at the time of disuse is concealed within the head. Having once gained access to the host they remain within its body until the caterpillar has become transformed into the perfect butterfly, or until their own sexual maturity is completed. Van Beneden thinks it probable that the males quit the host some time before the females, a view which, if correct, sufficiently accounts for the comparative scarcity of the males. According, however, to the experimental records of Von Siebold sexual congress occurs before the entrance of the worms into the caterpillars, an observation, which, if established, would render the entrance of male Mermes into the body of the insect host quite unnecessary —that is to say, of no necessity as regards the sexual function. In my opinion this is actually the case with Dracunculus, and explains how it happens that no male Guinea-worms have yet been discovered within the human host. So far as I am aware, the presence of the male Mermis in insect hosts has not yet been satisfactorily determined.

Genera.—*Gordius*, Linneus; = *Chordodes*, Moebius; *Mermis*, Dujardin and Siebold; =*Autoplectus*, Balsamo; = *Mermthoidum*, Kraemer; ? *Acicula*, Renier; *Dracunculus*, Lister; *Sphærularia*, Dufour; *Anguillina*, Hammerschmidt.

Sphærularia.—In the year 1836, M. Leon Dufour first applied this title to a remarkable Nematode, which he discovered in the abdominal cavities of two species of bee *(Bombus terrestris* and *B. hortorum).* The worm was subsequently found by Von Siebold in two other species of bee *(B. muscorum* and *B. sylvarum)*, and it remained for Mr. Lubbock to demonstrate that this parasite not only infested the above-mentioned insects, but also *B. lucorum*, *B. lapidarius*, *B. pratorum*, *B. subterraneus*, and *Apathus vestalis*. In a highly instructive memoir which appeared in the "Natural History Review" for January 1861, Lubbock furnishes us with a full description of the anatomy of the female Sphærularia, and he likewise appears to have discovered the male (Fig. 15). The female is nearly an inch in length, having a tolerably uniform diameter of $\frac{1}{15}''$ throughout, of a whitish colour, and bluntly pointed at either

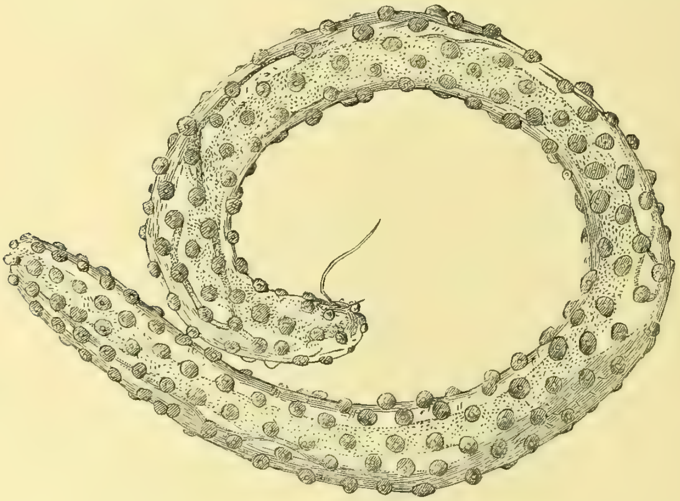

FIG. 15.—*Sphærularia bombi*, Dufour; male and female; × 15 diam.—Lubbock.

extremity. As one might gather from the name, its body is everywhere covered by numerous small warts or button-like projections, in all numbering about 800. These spherules are, for the most part, transparent, and according to Lubbock, each projects from $\frac{4}{1000}''$ to $\frac{6}{1000}''$ above the general smooth surface of the integument. There is neither mouth, œsophagus, intestine, nor anus; but in place of these there is a large fatty mass or *corpus adiposum* containing numerous cells. This peculiar organ, according to Lubbock, "is homologous, not with the whole intestinal canal of Nematodes, but only with the intestine; and we find, in fact, that in Gordius the œsophagus is very short, and opens at once into the anterior end of the *corpus adiposum;* so that to pass from this genus to Sphærularia, it would be necessary to shorten the œsophagus a little more, and then the wall of the *corpus adiposum* would be immediately attached to that of the body. So far, therefore, as concerns the *corpus adiposum* and the œsophagus, Sphærularia agrees neither with Gordius nor Mermis, nor, indeed, with one more than the other; since, if it agrees with *Mermis albicans* in the double series of large fat cells, it has no œsophagus, and in this respect more nearly resembles Gordius." The reproductive organs consist of a single ovary, uterus, and terminally situated vulva. These organs in the full-grown females contain ova in all stages of development up to the condition of advanced yolk segmentation; but it does not appear that embryonic formation takes place whilst the eggs are still *in utero.* "The young animals are born soon after the eggs are laid. They are about $\frac{1}{60}''$ in length, and $\frac{1}{2,500}''$ diameter at the broadest part." Before Mr. Lubbock conducted his inquiries the male appears to have been entirely overlooked; but there need be no surprise at this, seeing that there is a remarkable disparity between the sexes. The male Sphærularia is so extremely minute, that if it have ever been seen by previous observers, it is more than probable they have mistaken it for a young one. Mr. Lubbock calculates that "the male is more than 28,000 times smaller than the female. It may frequently be found sexually united to the female in a manner similar to that which obtains in *Sclerostoma Syngamus.* In the male Sphærularia, however, as in Gordius, there are no special copulatory organs, or, to say the least, there are no intromittent spicules.

OXYURIDÆ.—The little thread-worms though by many associated with the Ascarides proper, may be fitly and conveniently arranged in a separate family by themselves. Their minute bulk, fusiform shape, rounded oral aperture—which only resembles the triangular mouth of Ascaris in the expanded or protruded condition—their relative and strongly-marked disparity of size as regards the sexes, the spurious character of the so-called alæform appendages of the head, the triquetrous œsophagus and globular form of the stomach, the highly developed nervous system, and, more particularly, the single spiculum constituting the penis of the male—these several peculiarities, all taken together, appear to me sufficient to justify their separation from the true Ascarides. As I have elsewhere remarked, the genera and species of Nematoda display less tangible characters for systematic classification than those exhibited by other classes of helminths.

As a detailed account of the structure and development of the common thread-worm (*Oxyuris vermicularis*) will be given in the second division of this work, it will suffice my purpose to offer at present only a very general description of the anatomy of another member of this family. Our knowledge on this score is chiefly due to the investigations of Walter, whose elaborate account of the structure of *Oxyuris ornata* was first published in the eighth volume of Siebold and Kölliker's *Zeitschrift*, for 1857. The integument consists of an outer epidermis overlying a densely fibrous corium or true skin, which latter is also made up, apparently, of two layers. Externally, as in round worms generally, the body is marked by numerous transverse striæ, but the latter are so fine, even in the larger species, that they require considerable enlargement in order to bring them into view. The muscular system

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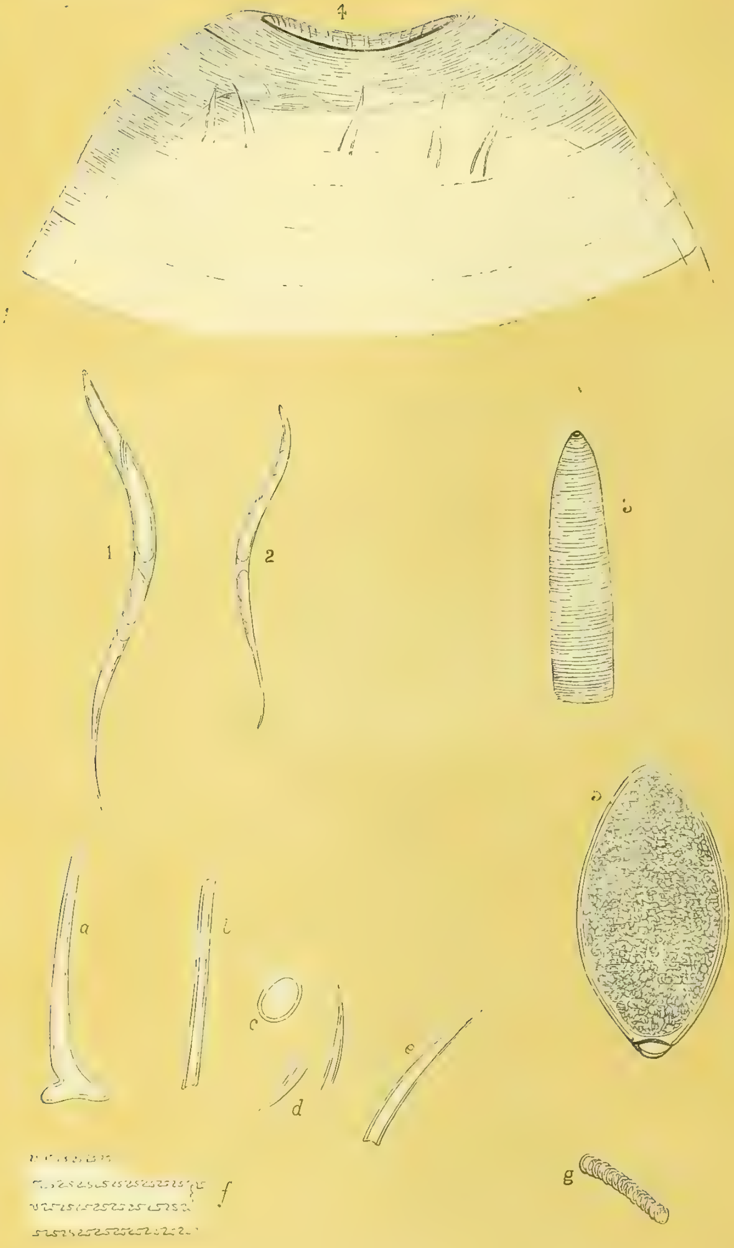

[illegible] Rudolphi.

G. Busk, delt.

is strongly developed, there being, according to Walter, four longitudinal muscles, two dorsal and two ventral, passing from one extremity of the body to the other. These lie immediately beneath the corium, being intimately blended with the latter in the regions of the tail and head.

In regard to the digestive system, some discrepancies have arisen in the descriptions of authors in consequence of the varying aspect of the worms under different conditions. Thus as regards the mouth, when the retractile papillæ are drawn inwards, all that we see is a simple, rounded oral aperture, such as is faithfully represented by Mr. Busk in the accompanying drawing of *Oxyuris curvula* (Plate IV., Fig. 4). At other times, the papillæ being temporarily exserted, the oral aperture presents a trilobate appearance, very similar to the condition normally characteristic of the genus Ascaris. From the observations of Wülstein and Wedl, moreover, it would seem that the papillæ are not invariably three in number, for, in the case of *O. vermicularis* and *O. ornata*, four such prominences may co-exist; whilst in the retracted buccal apparatus here figured, at least six or seven corresponding ridges may be seen, partially concealing eight or nine sharply-pointed dentules or stylets. These tooth-like structures appear to have been noticed by several observers, and Wedl has described a special dental apparatus in the stomach of *Oxyuris vermicularis*, which is probably distinctive. The long infundibuliform continuation of the buccal cavity is usually divided into a short pharyngeal portion and a long triangular œsophagus, the latter being separated from the globular stomach by a very marked constriction. This latter organ is succeeded by a second less marked constriction at the upper part of the intestinal canal, which is much expanded, and is by some regarded as part of the stomach itself. After this the alimentary canal gradually narrows into the intestine properly so called, and terminates by a wide anal cleft, which in the male also serves to give exit to the intromittent spiculum.

According to the description of Dujardin, as abridged by Carus,* the intestine of *Oxyuris curvula* is "filled with vegetable remains, which it finds in the alimentary canal of the horse, and which it reduces by the help of its oral armament. There stand three cross horny bars at the entrance of the mouth, which latter in the middle bears a conical hairy papilla, and on the side two or three furcated bristles. The oral aperture, which is surrounded by muscular fibres that stand perpendicularly upon its walls, and which is widened in front and behind, has a three-sided prismatical cavity, which is lined by a resisting membrane. Behind the horny bars there stand cross-folds beset with horny points. The middle narrower part has folds still higher, which at the hinder end make room for a row of closely-packed little folds, working like a file." As regards the nervous system, if Walter's remarkable description is correct, we have here a most complicated arrangement of cords and ganglia. In the first place a series of ganglia, constituting the so-called brain, which transmit filaments to the œsophagus and mouth as well as numerous connecting twigs to another set of ganglia on either side of the body. These lateral ganglia are also serially united by longitudinal cords, so that we have in fact three long trunks traversing the greater part of the body from end to end, the whole being united into one nerve-system by numerous transverse connecting filaments given off by the central ventral cord at tolerably regular intervals. The ventral cord itself is formed by two threads passing off from the upper part of the lateral cords a little below the œsophagal division of the cerebral ganglia. These form a single median trunk which divides in the region of the generative pore, so as to encircle the aperture, and again uniting passes downward to the anal opening, where it divides to form another complex series of caudal ganglia. Ultimately the divisions reunite below the anus, and forming a single true caudal or azygos ganglion, pass in the condition of a narrow solitary thread to the point of the tail. Notwithstanding the minuteness of these details (as originally given by Walter), the somewhat more recent investigations of Schneider, Eberth, and others, all tend to cast doubt on Walter's so-called nerve discoveries. It is even said that Walter himself has admitted his descriptions to be erroneous.

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* "Jahresbericht über die im Gebiete der Zootomie erschienenen Arbeiten." 1856. S. 36.

The reproductive system follows without much deviation the general Nematode type. The male apparatus, according to Kuchenmeister, consists of a simple uniform tube or a seminiferous duct, in which neither testis nor vas deferens can be clearly defined, the whole terminating in a grooved spiculum or penis, which during exsertion passes out by the anal cleft. A small accessory spicule, as in the genus Filaria, and a sucking disk placed at the caudal extremity, assist in fixing the parts during sexual congress. In the female the apparatus consists of a narrow oviduct or vagina, two broad uterine canals severally occupying the upper and lower halves of the body, terminating in narrow ovarian tubes with blind extremities. The vaginal outlet is situated near the middle of the abdomen, but varies somewhat in the different species; in *Oxyuris vermicularis* it is almost within the boundary of the upper third of the body.

Genera:—Oxyuris, Rudolphi; *Ptychocephalus*, Diesing; = *Pseudonymus*, Diesing; *Pharyngodon*, Diesing; *Mastigodes*, Zeder; = *Passalurus*, Dujardin; *Heterakis*, Dujardin; *Subulura*, Molin; *Cosmocerca*, Diesing; *Thelastoma*, Leidy; *Strepstostomum*, Leidy; *Allodapa*, Diesing.

CHAPTER V.

NEMATODA.

The Filaridæ—*Trichocephalus affinis* considered as a type—Wilson's investigations respecting its anatomical structure—The views of Kuchenmeister and of Eberth regarding the characters presented by the reproductive organs, compared with those severally entertained by Mayer, Eberth, and the Author—Embryonic development — Genera — *Simondsia paradoxa* — Cheiracanthidæ — Genera — Ascaridæ — Genera.

Filaridæ.—The typical genus of this family has hitherto served as a sort of refuge for destitute systematists puzzled where to place numbers of filiform nematodes, whose characters were only imperfectly known, or if known, were probably those of immature *ascarides.* Even at the present time it is not pretended that we are in a position to rectify many long standing errors in Nematode classification, yet it would be extremely desirable to separate the round worms into tolerably well defined family groups. In this work I offer an arrangement presenting only the merest approximation to that which I hope to see ultimately accomplished; knowing full well that a true natural grouping can only be obtained after a long-continued personal examination of every available type. The genus *Filaria* is variously defined by the most trustworthy entozoologists, and according to the definitions of some would appear to be inseparable from the Ascarides properly so called. Provisionally, I shall include in the above family title all those nematodes presenting the following characters:—body filiform, smooth or finely striated transversely, furnished with a simple round or triangular mouth, generally surrounded by a variable number of papillæ, head continuous with the body, anus terminable or nearly so, tail of the male obtuse, bluntly pointed or slightly expanded, penis consisting of a long spiculum, which is often accompanied by a short accessory piece. These characters will pretty well embrace all the genera I propose to include in the Filaridæ, but in the present stage of our knowledge it becomes extremely difficult to offer an arrangement which shall supersede the method adopted by Dujardin. Probably no author, past or present, has enjoyed such a practical acquaintance with the Nematodes as the late Professor at Rennes, and yet his mode of classification is not generally accepted. In this family I place Dujardin's osculant genus *Heligmus*, which although it displays a trilobate mouth is only furnished with a long solitary spiculum; and for similar reasons I also include in this family Diesing's singular genus *Peritrachelius*, as well as the genus *Stephanurus*, because the hexa-punctiform mouth of the latter and its truncate tail in the male (furnished with a single spicule only) will not permit its incorporation with the Ascarides proper.

In accordance with the design and scope of the present work it is not possible to do more than select a single genus to illustrate this Nematode family, numerically great in genera, as I have here represented it to be. The typical genus *Filaria* is, in itself, perhaps, one of the least interesting of the genera considered structurally, and therefore I select the closely allied genus Trichocephalus, as sufficiently characteristic of the family under consideration. Helminthologists have described some eight or ten different species as belonging to this genus, the two most common, and by their similarity of external characters liable to be confounded, being the common whip-worm of man, and that of our domestic ruminants. The former *(Trichocephalus dispar)* will be separately noticed in the second part of this work, and therefore the latter (*T. affinis)*, which is a comparatively little known species, may now engage our attention.

To the naked eye *Trichocephalus affinis* does not differ materially from the human species, but the anterior narrow or capillary portion is comparatively finer and longer. The male is readily distinguishable from the female by its spirally incurved tail, and this spiral is not precisely in the same direction or plane as the general falciform curvature of the thick body of the animal (Plate V., Fig. 1), but turns laterally and obliquely on one side, so as to form a sort of conchoidal projection. This feature was first remarked on and described by Mr. Erasmus Wilson,* and I have endeavoured to represent the same character in the accompanying plate (Fig. 4). The male is further distinguished from the female by its long spiculum, and also from the male of *Tricocephalus dispar* by the comparatively much greater length of the sheath surrounding the spicule; moreover, the position of the reproductive orifices in the two sexes is equally distinctive. With a pocket lens the surface of the worm appears smooth throughout; but when highly magnified, peculiar markings are seen on the anterior thin portion or capillary neck. This part presents a tolerably uniform thickness along its entire course, measuring about the $\frac{1}{120}$ of an inch transversely, but at the finely-pointed head immediately below the mouth the diameter is about the $\frac{1}{1000}$ of an inch only. In the fresh state, the head often appears lobed or furnished with lateral appendages, the aspect of which is very variable. Kuchenmeister has described the evanescent character of similar structures surrounding the mouth in *T. dispar*, and he regards these lobes as forming a peculiar organ, capable of eversion and inversion, and not as the mere result of accidental sarcode-formation. Mr. Erasmus Wilson, who has also noticed this structure, speaks of it rather more definitely in the following terms:—"Immediately below the point of the head," he says, "the integument is raised from the surface beneath, and more or less distended, so as to constitute a prominent transparent collar. In some of the specimens this collar was absent, but in the greater number it was present, either partially or completely expanded. Its purpose,

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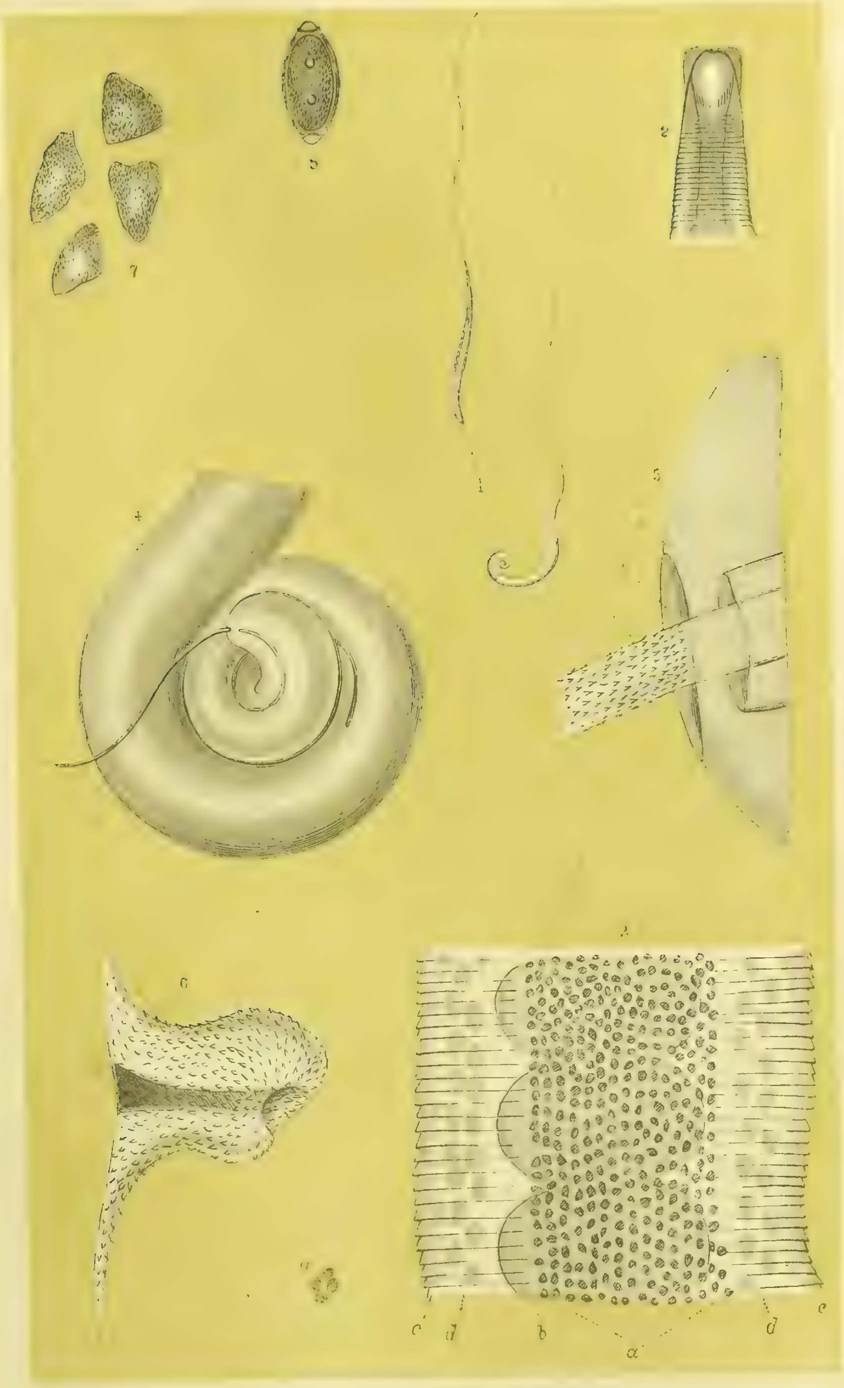
* See "The Veterinary Record and Transactions." Vol. ii., p. 47. 1846.



Porocephalus [illegible]

T. S. C., delt.

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I conceive to be, to fix the head in its position when buried in the mucous membrane in search of food." We are all agreed, therefore, as to the non-persistent character of this "collar," and I may observe in passing, that this is not the only structural appearance which alters somewhat under varying circumstances, produced either by agents directly affecting the worm itself, or by the manner in which it is brought into view. Thus I may instance also the very peculiar longitudinal band which commences a little below the head, and can be traced on one side of the neck the whole way down to the commencement of the so-called body. This band, which is remarkably distinct in fresh specimens, was first discovered by Dujardin in *T. dispar*, and he states it to consist of prominent and pointed papillæ. Wedl, as I suspect, unknowingly referred to it when speaking of certain little warts or spines passing round the animal upon the epidermis; but he also speaks of a band-like streak, which he compares to a structureless layer. Kuchenmeister, on the other hand, goes so far as to aver his opinion that "the streak is nothing but an optical phenomenon, but he, at the same time, compares the little prominences before-mentioned to the hooklets present on the intromittent organ of the male. According, however, to my own observations, this band is a genuine structure, and is made up of projecting, bluntly pointed, polygonal, epidermal cells, which, in certain adjustments of the focus, refract transmitted light so strongly that the band looks as if it consisted of a regularly arranged series of pigment spots (Fig. 3, *a*); at other times the centre of each cell becomes clear (*a*), and the irregularly polygonal character of each individual cell is rendered more apparent. On one side of the longitudinal band Dujardin also figures and describes a series of minute superficial papilla, which he associates with the festooned border of the band, but these markings are manifestly referable to the subjacent convolutions of the œsophagus. In the fresh condition of the worm, moreover, the imbricated dermal rings (*c*, *c*, Fig. 3) are beautifully distinct. These annulations do not extend all round on the surface of the neck, but cease at a little distance apart on either side of the longitudinal band. Speaking generally, therefore, the integument consists of a finely laminated epidermis, and a tolerably dense true corium, the latter being lined internally by two muscular layers—an outer one with transversely arranged fibres, and an inner one with longitudinal fibres. In addition to these, according to Wilson, " the lips are moved by means of a strong apparatus of longitudinal muscles."

The digestive apparatus conforms for the most part with the simple arrangement so prevalent in nematodes. The mouth is described by Wilson as being quadrilabiate and orbicular, " each of the lips being armed by two short conical hooks, which are curved inwards towards the oral aperture." These hooks do not appear to have been noticed by any other observer. The mouth itself leads into a narrow œsophagus, which is straight at first, but very soon becomes contorted, so as to display a series of regular convolutions, having a moniliform or beaded appearance (*a*, Fig. 3). To myself these regular foldings appeared quite convex at their borders, but Wilson says they are angular, " being retained in their position by a number of delicate ligamentous bands, which stretch from the outer wall to the inner surface of the integument." Wilson here evidently refers to the structures described by Kuchenmeister, as forming " a mass of small triangles, with their apices turned towards the intestine," and serving to connect the tubes with the parietes. Both Kuchenmeister and Wilson have noticed certain glandular structures in connection with the alimentary canal, but their nature is not clearly made out; and I have also observed in the capillary portion a regular series of oval cellules (*d*, Fig. 3), forming a loosely attached parenchyma within the perivisceral space. Speaking of the continuation of the tube, Wilson remarks that " the sacculated character of the first portion of the alimentary canal, and the strongly-marked bands which tie the dilatations to the inner surface of the integument, constitute together a well-defined line of demarcation between the capillary portion and the cavity of the body of the animal. Immediately beyond the last sacculus the canal contracts and is received into the dilated head of the abdominal intestine, forming in this situation a muscular valve. The abdominal intestine then pursues its course along the left side and inferior border of the cavity of the abdomen to the anus. This intestine is thick, and its lining membrane is studded with dark rugæ, which remind us of the rugous appearance of the gizzard of a bird. They are largest and most prominent in the middle third of its extent, and are arranged in longitudinal lines. At a short distance from the extremity of the tail the intestine suddenly contracts and becomes transparent, and is then continued in a straight line to the anus. This contracted and transparent portion of the intestine corresponds with the rectum. The anus is situated upon the lower or curved border of the animal, close to its blunt termination. It is an elliptical opening of moderate size, closed by a strong sphincter muscle." This description accords in all essential particulars with that which has been observed in *Trichocephalus dispar*, but Mr. Wilson does not accept the generally received view as to the functional character of the different parts. Without dwelling on this matter, I will merely observe, in passing, that the portion of the canal which he calls the "dilated head of the intestine" is manifestly the true stomach of Kuchenmeister and others. The mode of termination of the alimentary canal in the male is somewhat peculiar, the true anus being placed high up at a very considerable distance from the external or general cloacal outlet, the wall of this common tube becoming intimately blended with the sheath of the penis at a little distance above the final opening. Wilson's and Kuchenmeister's descriptions are quite clear and consistent, and I have therefore abandoned my previous notions where they were at variance with their authority on these points; but I have entire confidence in the results of my own examinations as regards the sexual organs, to which structures my investigations were specially directed.

With reference to the organs of generation in the female, Kuchenmeister states that there are no external appendages in *Trichocephalus* comparable to those known to exist in the allied *Trichosomata.* So far, however, from this being the case, there is, in the present species at least, a remarkably prominent and more or less hourglass-shaped sheath; this projecting vulva, if it may be so termed, being obliquely truncated at the free end, where it is also hollowed out, or rather inverted, to give origin to the centrally inclosed vagina, whose orifice is somewhat constricted (Plate V., Fig. 6). The surface of this appendage is supplied with small spines, precisely similar to those to be described in connection with the male intromittent organ; the spines being likewise retroverted. This observation is confirmed by the statements of Mayer, who has described their occurrence at the vaginal orifice of *T. dispar.* It also coincides with the account given by Wilson, who says, "the vulva is a short and transparent papilla, measuring $\frac{1}{200}$ of an inch in length, by as much in breadth. It is flattened at its extremity, somewhat larger at this point than nearer the body of the animal, and curved slightly backwards. On its external surface it is studded with numberless minute recurved spines, and it is traversed by the contracted canal of the excretory duct of the uterus, which follows the curve of the vulva, and terminates at its flattened extremity." Dr. Eberth of Wurzburg, however, in his otherwise admirable paper in Siebold and Kolliker's "Zeitschrift," denies the assertions of Mayer.* Dr. Eberth having discovered a series of long conical processes within the vagina of *T. dispar*, totally unlike those described by Mayer (Zeitschrift für wissen. Zool., Band 9, s. 367), Wilson, and myself, has inferred that the structures in question are the same as those seen by us. I translate and quote his own words:—"According to Mayer, these are similar in form and size to the spines on the appendix of the penis. By means of these backwardly directed points, the spicule, when introduced into the vagina, is said to be retained during the copulatory act. These statements," adds Dr. Eberth, " are not correct; the villi of the vagina are larger than the spines of the male, and their points on the contrary are directed forwards." It thus appears evident that our little spines are very different from the curious villi discovered by Dr. Eberth, unless, indeed, his description be altogether inaccurate; an assumption which we are scarcely at liberty to entertain. Both in *T. dispar* and *T. affinis* the vaginal orifice is placed at the upper part of the body just before it becomes narrowed to form the long neck, and the opening leads directly into a single capacious uterine sac, which passes downwards to within a little distance from the tail. In this situation it becomes suddenly narrowed, bends upon itself so as to form a tortuous ovarian tube, which, passing upwards to a point below the vaginal orifice, again returns to pursue a similar serpentine course, finally terminating in a free, narrow, tubular cœcal filament.

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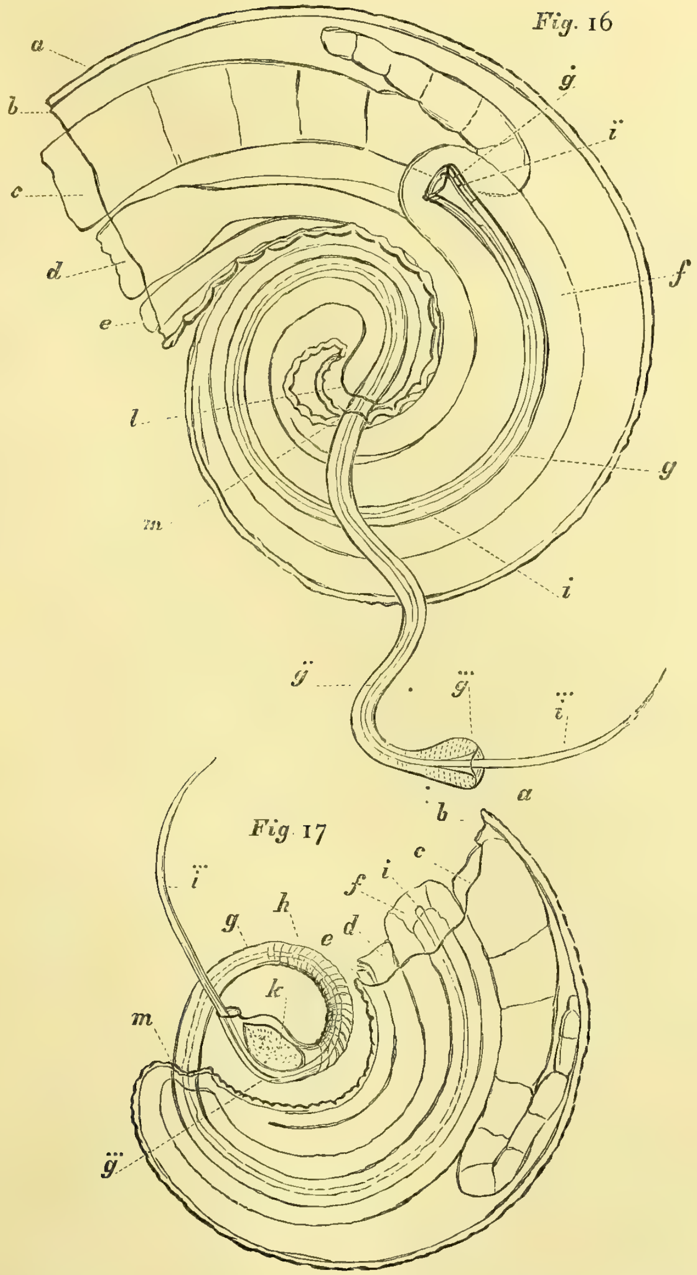
* "Die Generationsorgane von *T. dispar.*" *Zeitschrift* for April, 1860, p. 384.

In regard to the male reproductive apparatus, the testis commences by a bluntly-pointed cœcal sac, bent upon itself and situated a little above the caudal region. This sac passes upwards in a tortuous manner as far as the true stomach, where it suddenly retraces its course, becoming still more dilated. Its final mode of termination I have not myself independently made out, but Wilson, whose descriptions are generally very accurate, observes:—" At about the union of the anterior with the middle third of the abdomen, this sac contracts into a thick fleshy sphincter valve, and is there continued onwards as a large tube, with thick and fleshy walls to near the extremity of the tail, where it becomes narrower, and terminates by a small opening in the intestine." In regard to the intromittent organ, it may next be remarked that in the retracted condition it is to a very great extent independent of the essential organs just described, for its surrounding sheath is only embraced by the cloacal or intestinal tube a little above the caudal outlet. In the exserted condition, however, the sheath and the spiculum are both included within the cloacal cavity. The remarkable length of the penis and its membranous sheath is characteristic of *T. affinis* as compared with the human species. According to Wilson "it is a slender shaft, $\frac{1}{3000}$ of an inch in diameter, and from two to three lines in length. It is situated along the ventral border of the worm, occupying somewhat more than its posterior third. It is enclosed, in the first instance, by a thick envelope or sheath, and lies in contact with the internal surface of the integument; and, nearer the tail, it enters the intestine and carries with it a thin membranous sheath, which is prolonged to the anal opening. The apex of the style is conical and sharp; its base is broad and gives attachment to a strong muscular fasciculus, which arises at some distance farther forward from the longitudinal muscular fibres of the parietes of the animal, and performs the office of a retractor muscle." By the base of the spicule, I understand Wilson to refer to the upper or infundibuliform end, which I have represented in the accompanying outline drawing from nature (Fig. 16, i''). The membranous sheath itself is not invariably uniform in breadth, being often globular, flask-shaped, or pyriform at its free extremity, where the spicule emerges. Two of these varying conditions are represented in the annexed cuts (Figs. 16 and 17), whilst the ordinary uniform state of the sheath is shown in the Plate (Fig. 4). To myself these appearances were at first very puzzling, but I afterwards found that these varying conditions were simply due to the degree of protrusion at which the membrane had arrived. Externally the membrane is covered throughout with the characteristic minute, conical, sharply-pointed spines, whose apices are directed backwards towards the body of the animal. The lower part of the style is somewhat curved or scimitar-shaped, but I have not discovered any groove on its surface for conducting the semen, such as has been described as existing on the spiculum of *T. dispar*. In one case, however, I found the flask-shaped formation at the end of the sheath to contain a mass of seminal particles (Fig. 17, *k*), and behind this swelling the membrane was contracted at intervals so as to form a striking series of regular annulations.

Fig. 16

Fig 17



Figs. 16 and 17.—Caudal extremity of *Trichocephalus affinis.* Outlined, with the aid of a camera, from two separate specimens mounted and preserved in glycerine. *a*, epidermis; *b*, cutis; *c*, cœcal end of testis: *d*, seminal duct; *e*, intestine; *f*, muscle surrounding the sheath of the penis; *g*, sheath, and *ġ*, its infundibuliform base; *g̈*, inner boundary of the sheath; *g⃛*, flask or cup-shaped extremity of the sheath; *h*, transverse rings; *i*, spiculum; *ï*, base of the spicule, and *i⃛*, its free curved extremity; *k*, mass of spermatic particles; *l*, cloacal cavity; *m*, anus.—Original.

As in other nematodes at a certain stage previous to impregnation, the ova are triangular or irregularly polygonal in outline, and the thin limiting membrane by which they are surrounded encloses finely granular contents (Plate V., Fig. 7). In the perfectly developed egg, the external chitinous chorion presents the same characters as in *Trichocephalus dispar.* At either pole of the egg, where the shell terminates abruptly, an inner transparent membrane projects in the form of a papilla (Fig. 8). When fully developed, the ova have a longitudinal diameter of $\frac{1}{340}$ to the $\frac{1}{320}$ of an inch. In none of the eggs which I have examined were there any traces of an embryo, but I have commonly found them in the earliest stages of yolk-segmentation. Some little while ago Kuchenmeister expressed his opinion that *Trichocephalus* had some genetic relation with Trichina, but the series of able researches by Virchow and R. Leuckart, carried on independently, have shown this opinion to be erroneous. More recently, Davaine strove to determine the development and migrations of Trichocephalus by direct experiment, and accordingly he found that the embryonic formation only took place within the egg after the ova had been immersed in water for a period of six months. From this, therefore, it may be surmised that the escaped embryos ultimately gain access to our bodies in a passive manner when swallowed with the waters we drink. At all events it satisfactorily explains why my own feeding experiments with the fresh eggs of *Trichocephalus affinis* from a Giraffe, merely led to a negative result.

Genera.—Monopetalonema, Diesing; *Gongylonema,* Diesing; *Dicheilonema,* Diesing; *Tricheilonema,* Diesing; *Tetracheilonema,* Diesing; *Filaria,* Müller; = (in part) *Fusaria,* Zeder; = *Thelazia,* Bosc; *Dracunculus,* Kaempfer; *Icthyonema,* Diesing; *Dipetalonema,* Diesing; *Solenonema,* Diesing; *Filaroides,* Van Beneden; *Trichosoma,* Dujardin; = *Hamularia,* Rudolphi; = (in part) *Capillaria,* Zeder; *Trichocephalus,* Dujardin; = *Trichuris,* Roederer; *Onchophora,* Diesing; *Thominx,* Dujardin; *Eucoleus,* Dujardin; *Calodium,* Dujardin; *Liniscus,* Dujardin; *Sclerotrichum,* Rudolphi; *Onchocerca,* Diesing; *Trichina,* Owen; *Eucamptus,* Dujardin; ? *Proleptus,* Dujardin; = *Spiroptera,* Dujardin; = (in part) *Physaloptera,* Rudolphi; = *Acuaria,* Bremser; = *Fissula,* Bosc; *Simondsia,* Cobbold; *Spirura,* Blanchard and Leidy; *Dispharagus,* Dujardin; = (in part) *Histiocephalus,* Diesing; *Tropidocerca,* Diesing; = *Tropisurus,* Diesing; = *Tetrameres,* Creplin; *Spiropterina,* Van Beneden; *Cheilospirura,* Diesing; *Physocephalus,* Diesing.

Simondsia.—In this place I think it right to say a few words in regard to a remarkable Nematode which exists in the collection of Professor James Beart Simonds, of the Royal Veterinary College. The worm in question has been regarded by Mr. Simonds as a species of *Strongylus,* but I am inclined to think that its affinities will place it nearer to the genus *Spiroptera.* At present I have only examined the female, which is characterised by the possession of a multitude of large tentacle-like appendages surrounding the neck. These processes, by their aspect, remind one of the so-called branchial projections on the back of *Eolis,* but in this worm I believe them to be special folds formed for the lodgement of unusually developed uterine organs. The female is about three-quarters of an inch in length; numerous specimens being discovered by Mr. Simonds lodged within cysts occupying the walls of the stomach of a German hog which died at the Zoological Society's Menagerie, Regent's Park. With the discoverer's permission, I have named the species *Simondsia paradoxa.*

Cheiracanthidæ.—I may here bring together, as a family, several curious nematode genera, having the body usually more or less armed by spiny developments on the integument, and having the head distinct from the body. Some of them support only a single spiculum, others have two spicules of nearly equal length. I also include in this family, as aberrant types, the genera *Heterocheilus, Ancyracanthus,* and *Aspidocephalus,* which form a sort of connecting link between the Cheiracanths and the true Ascarides on the one hand, and between this family and the *Filaridæ* on the other. In *Heterocheilus* the surface of the body is not clothed with spines, but the mouth in both sexes is formed, as it were, by the approximation of two dissimilar, three-cleft chitinous lips, whilst the tail of the male terminates in a strongly curved and sharply pointed hook. The other genera have spinous, or other peculiar developments about the head. In regard to Curling's genus *Dactylius*, of which a more particular account will be given hereafter, one might at first be disposed to place it with the Cheiracanths, to which it certainly bears a very striking resemblance, but the absence of any spicule in the male, its pulsating dorsal vessel, and other annulose characters, clearly show that it cannot be regarded as a true helminth.

Genera.—*Cheiracanthus*, Diesing; = *Gnathostoma*, Owen; *Liorhynchus*, Rudolphi; = *Goezia* and *Cochlus*, Zeder; *Lecanocephalus*, Diesing; *Ancyracanthus*, Diesing; *Aspidocephalus*, Diesing; *Heterocheilus*, Diesing; = *Lobocephalus*, Diesing; *Echinocephalus*, Molin; *Hystrichis*, Dujardin; *Hystrignathus*, Leïdy; *Conocephalus*, Diesing; *Ancyracanthopsis*, Diesing; *Elaphocephalus*, Molin; *Stenodes*, Dujardin; *Cosmocephalus*, Molin.

Ascaridæ.—By placing within this family only those genera, the members of which display a conspicuous trivalved mouth, coupled with a double spiculum in the male, we necessarily reduce it to very narrow limits. I think this is an arrangement which ought to be allowed to stand, whatever mode of Nematode classification be finally adopted. In the typical genus the valves form three nearly equally developed, prominent, convex lobes which, meeting in the centre, form, in the closed condition of the mouth, a triquetrous groove, whose margins are sometimes denticulated. In *Heterakis* the valves are less prominent and unequal. Associated with these characters we find the body more or less narrowed and acuminate at either extremity; the surface is finely striated transversely, and there are generally distinct indications of two or four longitudinal, relatively equidistant lines passing from head to tail. These lines correspond with the water-vascular and nervous systems. The male is comparatively small; has the tail gracefully coiled upon itself towards the ventral aspect, and is in this situation often furnished with two membranous, winged appendages, laterally disposed, so as to assist in the copulatory act. Sometimes also there are two rows of papillæ or tubercles, and occasionally a sucking disk which is placed immediately in front of the anus (Dujardin). In the female the tail is usually longer and straight; the vulva being situated, ventrally, a little way in advance of the centre of the body. The eggs are either elliptical or globular; several of the species being viviparous (Dujardin).

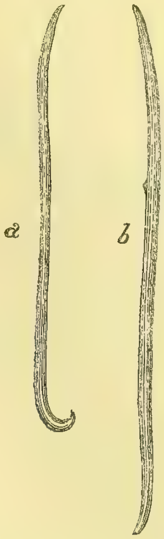


FIG. 18.—Two specimens of *Ascaris osculata*, Rudolphi; from the stomach of the common seal (*Phoca vitulina*). Male and female. Natural size.—Original.

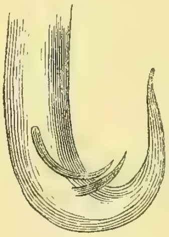


FIG. 19.—Caudal extremity of a male *Ascaris retusa*, Rudolphi; from the rectum of a Weasel-headed Armadillo (*Dasypus sexcinctus*). × 25 diam.—Original.

As the structure and development of *Ascaris lumbricoides* and *A. mystax* will be described in the second part of this work, it is here unnecessary to select any particular type for illustration.

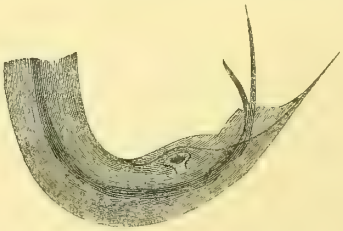


FIG. 20.—Caudal extremity of a male *Ascaris vesicularis*, Froelich; from one of the intestinal cœca of a Ring-necked Pheasant (*Phasianus torquatus*). × 30 diam.—Original.

Genera.—*Ascaris*, Linneus; = *Lumbricus*, Werner; *Heterakis*, Dujardin; *Heligmus*, Dujardin; *Peritrachelius*, Diesing; *Acanthocheilus*, Molin; *Crossophorus*, Hemprich and Ehrenberg; ? *Atractis*, Dujardin; *Ozolaimus*, Dujardin.

CHAPTER VI.

NEMATODA.

Strongylidæ—Genera—The *Sclerostoma Syngamus* as a type, with a particular account of the *gape* disease which it occasions—Structure and development—Remedial methods—The genus *Prosthecosacter*—Organization of *P. convolutus*—Mode of reproduction—Cucullanidæ—Genera.

Strongylidæ.—The varied members of this family present one or two characters in common, whilst several others prevail almost throughout the entire group. In all the body is round, and sometimes very much elongated and filiform. The mouth is either round, oval, or triangular, frequently very large, naked or armed with a horny pharyngeal armature; the latter forming either a single globular piece, or made up of several distinct pieces. Tail of the male furnished with a bursa, usually emitting two spicules; in some the place of the bursa is occupied by two divergent membranous lobes.

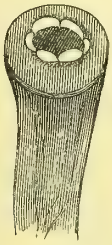


Fig. 21.—Cephalic extremity of *Eustrongylus papillosus*, Diesing; from the oral cavity of a crane (*Grus antigone*). Magnified.—Original.

Genera.—*Strongylus*, Müller; ? *Uncinaria*, Froelich; *Eustrongylus*, Diesing; = *Diocotophyme*, Collet-Meyret; *Sclerostoma*, Rudolphi; = *Anchylostoma*, Dubini; = *Syngamus*, Von Siebold;

= *Cyathostoma*, Blanchard; *Dochmius*, Dujardin; *Prosthecosacter*, Diesing; = *Pharurus*, R. Leuckart; = *Pseudalius*, Dujardin; *Stenurus*, Dujardin; *Diaphanocephalus*, Diesing; *Stephanurus*, Diesing; *Deletrocephalus*, Diesing; ? *Dicentrocephalus*, Wedl.

Sclerostoma.—As the best known species of this genus has a special practical interest in relation to the development of the gape-disease in fowls, I shall here offer a rather particular account of its history, structure, and development.

In the year 1799, a letter from Dr. Andrew Wiesenthal, Professor of Anatomy at Baltimore, U. S., was published in the second volume of the "Medical and Physical Journal," containing an account of a parasite infesting the trachea of fowls and turkeys in America. As this brief communication bears the early date of May 21st, 1797, and constitutes the first public record that we have respecting the above-named entozoon, I will introduce the subject by a short extract from Dr. Wiesenthal's letter. "There is," he says, "a disease prevalent among the gallinaceous poultry in this country, called the *gapes*, which destroys eight-tenths of our fowls in many parts, and takes place in the greatest degree among the young turkeys and chickens bred upon old-established farms. Chicks and poults, in a few days after they are hatched, are found frequently to open their mouths wide and gasp for breath, at the same time frequently sneezing and attempting to swallow. At first the affection is slight, but gradually becomes more and more oppressive, and it ultimately destroys. Very few recover; they languish, grow dispirited, droop, and die. It is generally known that these symptoms are occasioned by worms in the trachea. I have seen the whole [windpipe] completely filled with these worms, and have been astonished at the animals being capable of respiration under such circumstances."

Any one who has witnessed birds suffering from the above-named malady, known in this country also by the name of *gapes*, will at once have recognized the close accuracy of Dr. Wiesenthal's description; and, so far as the phenomenology of the disease itself is concerned, very little more has been added in the accounts which have from time to time appeared. The publication of the letter above referred to is accompanied by a simple woodcut representing one of the worms of its natural size, and another view of the same example three or four times magnified. The figures evidently depict a female; but the position of the reproductive orifice is not indicated, neither is the question of sexuality discussed.

On the 1st of August, 1808, the English naturalist, George Montagu, F.L.S., made a communication to the Wernerian Society, his paper being entitled "Account of a species of *Fasciola*, which infests the trachea of Poultry, with a Mode of Cure." Montagu does not appear to have been aware of the existence of any previous record on this subject, as we gather from an editorial note appended to his memoir in the first volume of the Wernerian Society's Transactions. Fortunately, our author gave a scientific description of the parasite, which consequently led to its being specifically noticed, under various titles, in the systematic works of Rudolphi, Dujardin, and Diesing; but by far the most elaborate accounts of this animal are due to the writings of Von Siebold.

The *Sclerostoma Syngamus* has been found in the trachea of the turkey, domestic cock, pheasant, partridge, black stork, magpie, hooded crow, green woodpecker, starling and swift; and I do not doubt that this list might be very much extended if ornithologists would favour us with their experience in the matter. Hitherto I have been surprised to find how few of those to whom I have mentioned the subject appear to be acquainted either with the nature of the parasite or with the various methods to be adopted in curing the disease to which its presence in the windpipe gives rise.

Having, during the month of July, 1860, obtained a fowl suffering from the gapes, I operated upon it in the following manner:—A very small portion of carded wool having been dipped in chloroform and placed in front of the bird's nostrils, it was soon rendered perfectly insensible. The skin of the neck was then divided and the trachea slit up to the extent of about a quarter of an inch; and introducing one prong of a pair of common dissecting forceps, I removed seven Sclerostomata. Six of these parasites were united in pairs, the odd worm being a female from which the mate had in all likelihood been rudely torn during the withdrawal of the forceps; and if so, it escaped my observation. After I had closed the external wound with a single thread, the bird was permitted to wake out of its artificial sleep; and, notwithstanding that it had parted with a drop or two of blood, it soon recovered its legs, and ran about the table as vigorously as ever. Moreover, as if this were not enough to satisfy me as to its almost instantaneous cure, in a very few minutes afterwards it demolished the contents of a saucer partly filled with bread previously steeped in milk. An occasional gape was caused by an accumulation of frothy mucus within the injured trachea; but this obstruction the bird soon got rid of, by a few shakes of the head attended with sneezing. The only subsequent inconvenience to the bird arose from emphysematous distention of the cellular tissue of the head and neck. This was on two or three occasions relieved by a slight puncture of the extremely thin integument, the emphysema ceasing to form after the external wound had healed. Some months afterwards I caused the bird to be killed, and on dissecting the neck, although there was no scar externally, a distinct cicatrix indicated the site of the operation on the trachea—the divided cartilaginous rings, six in number, being united only by a thin layer of connective tissue.

Reverting now to the worms extracted from the trachea, I observe, in the first place, that the females have an average length of $\frac{5}{8}$ of an inch, the males scarcely exceeding $\frac{1}{8}$ of an inch. In both sexes the bodies are tolerably uniform in breadth throughout; that of the female measures $\frac{1}{85}$, whilst the transverse diameter of the male is only from $\frac{1}{60}$ to $\frac{1}{50}$ of an inch. The heads are relatively even more disproportionate. In the fresh state the mouth of the female was seen to be furnished with six prominent chitinous lips; but the conspicuousness of the latter became much lessened after the specimens had been placed in spirit (2, fig. 22). In both sexes the surface of the body is quite smooth; but the female displays a series of spirally arranged lines, which at first sight convey the idea of a natural twisting of the body; this torsion, however, is more apparent than real, being likewise more marked in some individuals than in others. The body of the female, towards the tail, exhibits a decided tendency to fold upon itself; and in one example this feature was very significant (3, fig. 22). The lower part of the body preserves a tolerably uniform thickness almost to the extremity, where it is suddenly constricted to form a short, narrow, mucronate, pointed tail, scarcely visible to the naked eye. Employing a pocket lens, it is easy to observe through the transparent integument the spacious

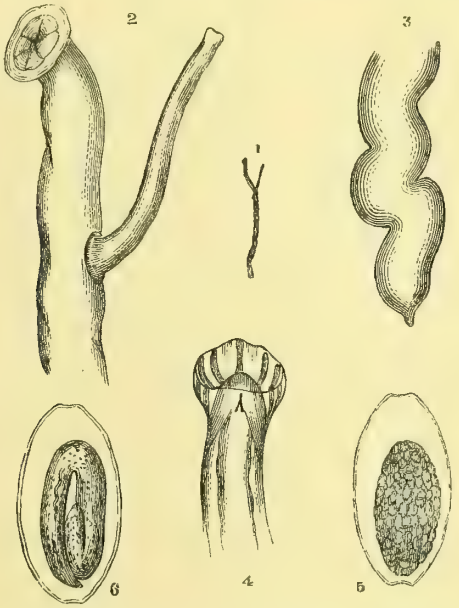


FIG. 22.—*Sclerostoma syngamus*, Diesing.—1. Male and female; natural size. 2. Upper part of the same, showing more especially the six-lobed circular lip of the female, and the mode of sexual union; enlarged. 3. Lower end of the body of the female, with its mucronate caudal appendage; enlarged. 4. Lower end of the body of the male, inverted to show the cup-shaped bursa, hard rays, lateral muscles, bifurcate penis, digestive tube, and rounded tail; magnified 30 diam. 5. Mature egg; × 220 diam. 6. Egg, with contained embryo; × 220 diam.—Original.

digestive canal, surrounded on all sides by sinuous foldings of the ovarium, tuba, and uterus—the vagina terminating laterally at a point corresponding with the line of the upper fourth of the body. Here the male is usually found rigidly affixed by means of a strong, membranous, sucker-like bursa, which proceeds from the lower end of its body. This cup-shaped appendage is formed out of a folded extension of the dermal covering, which thus envelopes the centrally enclosed and rounded tail (4, fig. 22). The membrane of the bursa is simple, transparent, undivided, smooth at its free border, and strengthened internally by a series of projecting rays, the precise number of which I could not ascertain with certainty. Probably there were twelve; but I only recognized nine. These rays appear to me simple, firm, chitinous bands, whose purpose is to fix and support the bursa, in the same manner as we find the whalebone rods employed to distend the hood of an umbrella. Acting antagonistically to these rays we also find a pair of strong retractor muscles, which, taking their origin a little higher up on either side, converge below to be inserted into the base of the cup-shaped bursa (4, fig. 22). In addition to these structures, a very distinct view of the penis can be gained by transmitted light. This organ, in the retracted condition, is entirely concealed within the caudal prominence. It is very small, only about the $\frac{1}{225}$ of an inch in length, and consists of two narrow cylindrical spicules, which, though distinct, are firmly united at their lower third.

In regard to the peculiar mode of union of the sexes, it becomes an interesting point to ascertain whether there be an actual incorporation of the substance of the copulatory organs during or after the act of impregnation. In my specimens none of the three pairs were organically united, and I succeeded in separating one pair very readily. Dujardin speaks of them as being soldered together, whilst the statements of Von Siebold are still more explicit. In connection with this subject, the latter observer makes the following comment:*—"The two sexes of almost all round worms are united only at the time of copulation. The male of *Heteroura androphora* has also the habit of remaining connected with its mate beyond the period of copulation; here, thus, there is a continuous union of the two sexes without a growing together; and in *Syngamus trachealis* there is ultimately a lasting continuity of the sexes by means of an actual growing together."

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* Wiegmann's Archiv, 1836, p. 106.

Having entire confidence in Von Siebold's statement, I am bound to conclude that the sexual union in my specimens had only recently been effected; but, admitting this to have been the case, one naturally asks in what manner can the mature eggs make their escape, seeing that the vagina is blocked up by the intromittent organ and bursa of the male? Clearly the eggs can only escape by an eventual breaking up of the body of the parent; this result, however, is quite admissible, as it constantly happens in the cestode proglottides, where the vaginal orifice is too small to allow of the escape of the eggs with their contained six-hooked embryos. The eggs of *Sclerostoma Syngamus* are comparatively large, measuring longitudinally as much as the $\frac{1}{250}$ of an inch, their transverse diameter being just half the above measurement; the length of the yolk is $\frac{1}{350}''$ from pole to pole. The process of segmentation of the yolk accords with that observable in nematodes generally, the spherical cellules represented in the accompanying drawing (5, fig. 22) averaging a breadth of only $\frac{1}{2500}$ of an inch. The egg itself is oval, and bordered by two extremely delicate and transparent envelopes, whose curvatures at either pole are slightly interrupted, and the eggs consequently present truncated ends when viewed in profile. Many of the ova contain fully formed embryos; and in the centre of the lower third of the body of one of them I distinctly perceived an undulating canal, probably constituting the, as yet, imperfectly formed intestinal tube. By whatever mode the young make their *exit* from the shell, it is manifest that prior to their expulsion, they are sufficiently developed to undertake an active migration. Their next habitation may occur within the bodies of certain insect larvæ or even small land molluscs; but I think it more likely that they either enter the substance of vegetable matters, or bury themselves in the soil at a short distance from the surface.

It remains for me only further to notice the various methods which may be adopted with the view, on the one hand, of checking the destructive influences of this parasite, and, on the other, of limiting its abundance:—

First. When the worm has taken up its abode in the trachea of fowls and other domesticated birds, the simplest plan consists, as Dr. Wiesenthal long ago pointed out, in stripping a feather from the tube to near the narrow end of the shaft, leaving only a few uninjured webs at the tip. The bird being secured, the webbed extremity of the feather is introduced into the windpipe. It is then twisted round a few times and withdrawn, when it will usually happen that several of the worms are found attached. In some instances this plan entirely succeeds; but it is not altogether satisfactory, as it occasionally fails to dislodge all the occupants.

Secondly. The above method is rendered more effectual when the feather is previously steeped in some medicated solution which will destroy the worms. Mr. Bartlett, Superintendent of the Zoological Society's Gardens, employs salt for this purpose, or a weak infusion of tobacco; and he informs me that the simple application of turpentine to the throat externally is sufficient to kill the worms. To this plan, however, there is the objection, that, unless much care be taken, the bird itself may be injuriously affected by the drugs employed.

Thirdly. The mode of treatment recommended by Mr. Montagu appears worthy of mention, as it proved successful in his hands, although the infested birds were old partridges. One of his birds had died from suffocation; but he tells us that "change of food and change of place, together with the infusion of rue and garlic instead of plain water to drink, and chiefly hempseed, independent of the green vegetables which the grass plot of the menagerie afforded, recovered the others in a very short time."

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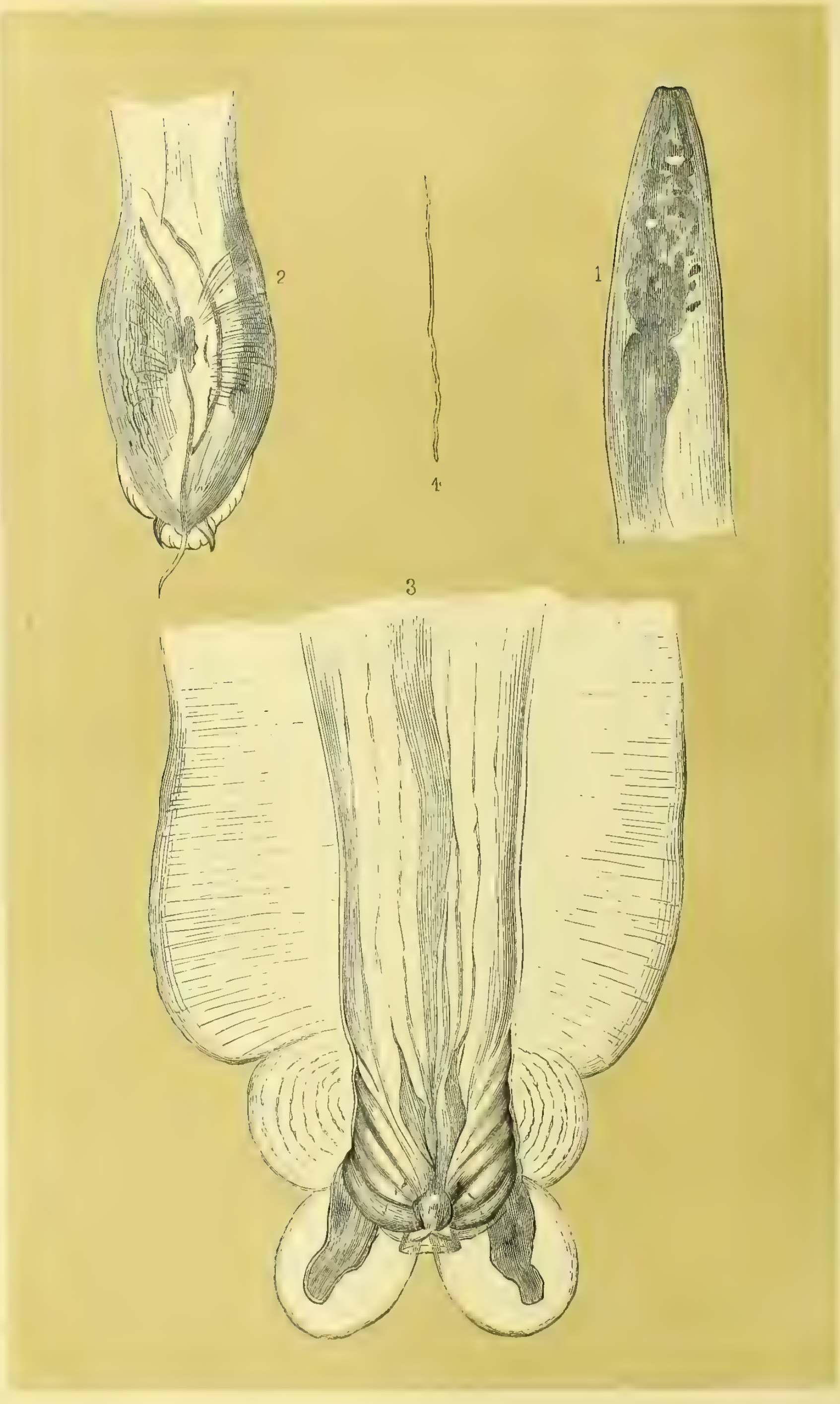

Prosthecosacter convolutus. Diesing.
(Male.)

G. Busk, delt.

Fourthly. The plan I have here adopted by way of experiment. This method is evidently only necessary when the disease has so far advanced that immediate suffocation becomes inevitable; or it may be resorted to when other methods have failed. In the most far-gone cases instant relief will follow this operation, since the trachea may with certainty be cleared of all obstructions.

Lastly. Perhaps the most essential thing to be observed, in view of putting a check upon the future prevalence of the disease, is the *total destruction of the parasites after their removal*—a precaution, however, which cannot be adopted if Mr. Montagu's mode of treatment is followed. If the worms be merely killed and thrown away (say, upon the ground), it is scarcely likely that the mature eggs will have sustained any injury. Decomposition having set in, the young embryos will sooner or later escape from their shells, migrate in the soil or elsewhere, and ultimately find their way into the air-passages of certain birds in the same manner as their parents did before them.*

Prosthecosacter.—Three well-defined species of this curious genus are known to infest the common porpoise, whilst a fourth has been found in the narwhale. The three forms first mentioned (*Prosthecosacter inflexus*, *P. convolutus*, and *P. minor*) are readily distinguishable from each other by their relative size and length, and also more especially by the form of their caudal extremities. The females of *P. inflexus* are capable of attaining a length of nine inches, those of *P. convolutus* may be upwards of an inch and a half in length, whilst those of *P. minor* have not hitherto been known to exceed the inch. The species described by Leuckart, from the narwhale (*P. alatus*), is only half an inch long. All the forms from the porpoise were met with by Professor Quekett; two of the species have been noticed by myself, and one of them has been very carefully anatomised by Mr. Busk, from whose drawings the accompanying plates have been executed. Probably several other species will be discovered when the lungs and cranial sinuses of the larger cetacea are carefully examined for this purpose. The form (*P. convolutus*) here represented is the least known of the three infesting the porpoise. On the Continent it has only been dissected by Kuhn and Eschricht, whilst the other species have not only been examined by these authors, but also by Raspail, Dujardin, Von Siebold, Van Beneden, and several others.

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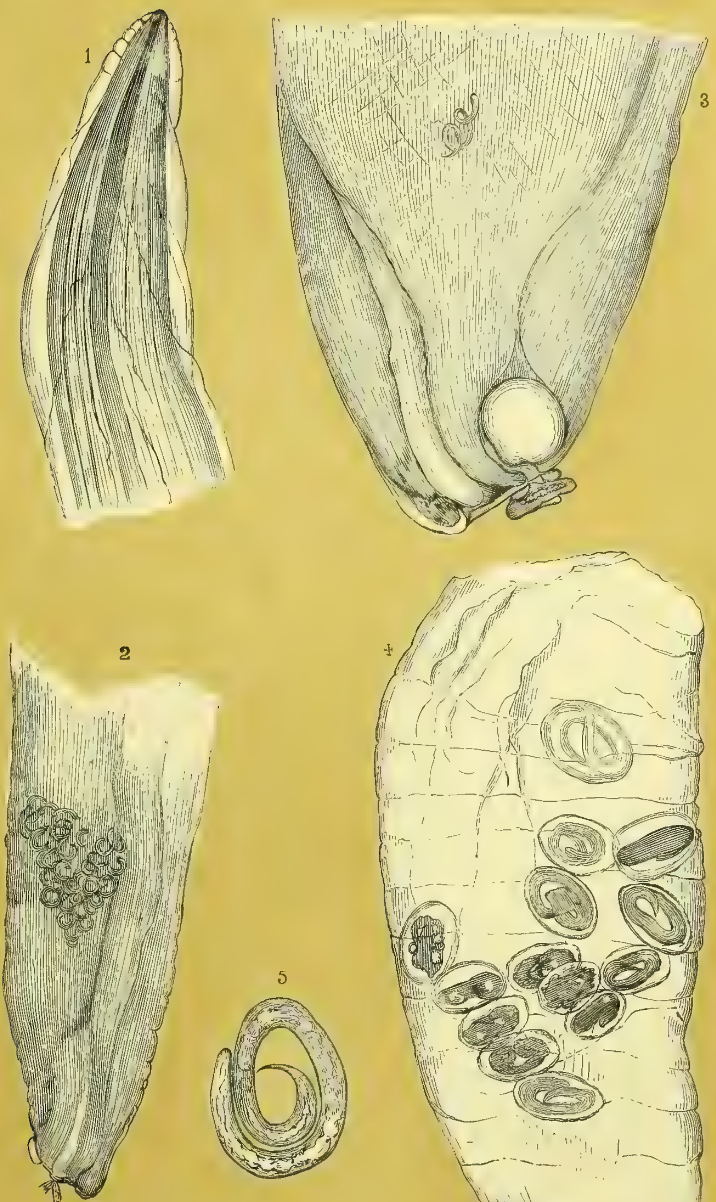
* The foregoing remarks form part of a communication published in the Linnean Society's Proceedings for 1861. The paper was also reprinted in "The Field" of June 22nd in the same year, Vol. xvii., No. 443, p. 550; and likewise in the "Edinburgh Veterinary Review," Vol. iii., p. 439, 1861.

According to previously published observations, the male of *P. convolutus* acquires the length of an inch, but in Mr. Busk's specimens one was fully fifteen lines long, whilst from the condition of the internal reproductive organs he was even led to believe that it was not quite fully grown. To the naked eye, and also under magnifying glasses of considerable power, the surface of the body appears smooth, but under the one-inch objective, fine transverse striæ are visible at all parts of the body. In the immediate neighbourhood of the mouth, when the worm is viewed from above, these striæ form a regular series of concentric circles, surrounding the mouth, which occurs in the condition of a simple rounded aperture devoid of any prominences or lips. In the male (Fig. 1, Plate VI.) the head is abruptly truncate, uniform and continuous with the trunk; but in the female (Fig. 1, Plate VII.) it is decidedly pointed, the conical neck or upper end of the body being bordered by a somewhat irregular folding or twisting of the thick diaphanous epidermis. This appearance is not only peculiar, but is believed to be distinctive of the species. At other regions of the body in the female this prominence of the transparent cuticle is less marked, but at the caudal extremity, both above and below the anal orifice, similar diaphanous foldings occur (Figs. 2 and 3, Plate VII.) In the male *P. convolutus* the outer integumentary layer is uniformly developed and closely applied to the dermis over the whole anterior and middle part of the body; but on approaching the tail, the epidermis suddenly spreads out on either side to form a pair of

PLATE VII.



Prosthecosacta convolutus, Diesing.
(Female.)

G. Busk, delt.

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membranous wings analogous to those observable in many true Ascarides. In this situation also the calibre of the body itself is considerably increased (Fig. 2, Plate VI.) In the genus Prosthecosacter generally, these wings are prolonged beyond the caudal extremity in the form of lobed appendages or tentacula, but they vary in shape in the different species of the genus. In *P. convolutus* they are perfectly oval, transparent, and free from either longitudinal or transverse striæ. In their interior are two fleshy or muscular papillæ, protected by a fibrous envelope or extension of the true dermis. These organs are probably designed to assist in the copulatory act. Between the tentacular lobes and the alæ proper, there are also two intermediate membranous folds, whose surfaces, though devoid of transverse striæ, display a series of parallel vertical plicæ, which are not always equally conspicuous; and at the extremity of the tail, in the central line, there is also a thin sucker-like disk, apparently due to the free protruding end of the sheath of the penis. This latter organ is double or bifurcate, the separate divisions being very long, filamentary, and uniform in thickness throughout; whilst within the body they are readily distinguished by their bright, brownish, yellow colour (Fig. 2, Plate VI.) In *P. inflexus* the horns of this organ are comparatively short, thick, and unciform.

The digestive system, speaking generally, consists of a simple tube passing in a straight direction from mouth to anus; but the œsophageal portion is very well defined, and is succeeded by a short stomachal bulb, which opens into the club-shaped, capacious upper end of the long intestine (Fig. 1, Plate VI.) In the male the rectum appears to terminate in a general cloacal cavity, having its final outlet between the caudal lobes; but in the female the lower end of the intestinal tube opens separately by a distinct anal orifice situated immediately behind the vulva, and almost at the extremity of the peculiar obliquely truncated tail (Fig. 3, Plate VII.)

The internal reproductive organs as developed in the male consist of a simple tubular secreting gland forming the testis, which is succeeded by a single vas deferens, terminating in the cloacal cavity. The bifurcate penis lies immediately in front, being inclosed in a separate sheath capable of partial protrusion at the cloacal outlet. In the female the essential sexual organs form two long uterine or ovarian tubes filling the interior of the body and passing downwards towards the tail, where they combine to form a common broad oviduct, which latter opens by a constricted orifice directly in front of the anus (Fig. 3, Plate VII.) In front of the vulva and directly in contact with the anterior border of the vaginal or narrow portion of the oviduct there is placed a large spherical vesicle which projects externally on the right side of the tail. The nature of this development is not very obvious, but it may possibly assist in the sexual act by offering to the tentacular-lobed appendages of the male a point of resistance for the full development of their clasping action.

All the species of this genus reproduce viviparously. If the worms are examined in the fresh state the young may occasionally be seen to escape by the vaginal orifice. Van Beneden noticed this phenomenon in *Prosthecosacter inflexus*, and the same thing was observed by Mr. Busk in *P. convolutus.* In the instance here illustrated one of the embryos is seen in the act of emerging, its caudal extremity being still lodged within the vulva of the parent (Fig. 3, Plate VII.) In the fresh worm one may also see, under the magnifying glass, numerous young coiled together within the oviduct (Fig. 2, Plate VII.), and the last-named organ widens out into a capacious sac at a little distance from the end of the tail (Fig. 3). Speaking roughly, the embryos measure about the $\frac{1}{300}$ of an inch in length, by the $\frac{1}{5000}$ of an inch in breadth. Higher up within the uterine and ovarian ducts, the ova may be seen in all stages of development, according to the particular region of the tube under examination (Fig. 4, Plate VII.) In their full-grown condition, the eggs have a longitudinal diameter of $\frac{1}{1100}''$ by a transversal measurement of about $\frac{1}{1700}$ of an inch. So far as I am aware, the essential act of fecundation and the phenomena of the development of the ova, as they occur prior to impregnation, have not been studied in any member of this genus; and we are still uninformed as to the migrations of the young after their escape from the parent. In all probability the embryos enter the bodies of various fishes before they have acquired sexual maturity, and are thence passively transferred to the stomachs of cetacea, whence they bore their way through the tissues into the bronchi and pulmonary blood-vessels. Though usually found in the above situations they are also particularly partial to the cranial sinuses; the *Prosthecosacter minor* being frequently lodged within the cavity of the tympanum. Both Mr. Quekett and myself found examples of *Prosthecosacter inflexus* occupying the chambers of the heart.*

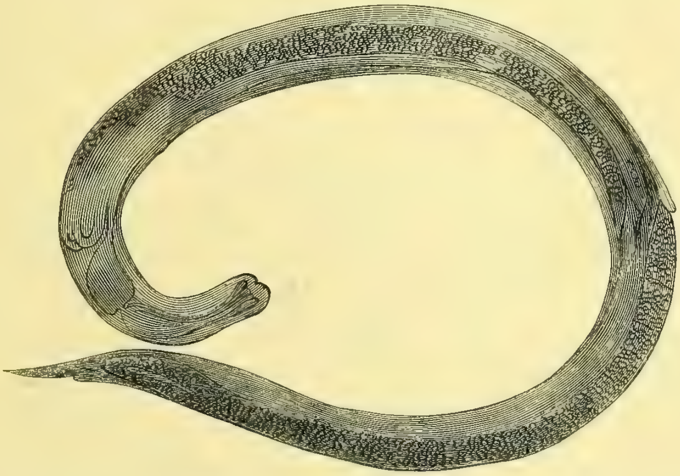

FIG. 23.—*Cucullanus foveolatus*, Rudolphi; from the intestine of the common plaice (*Platessa vulgaris*). Female; × 15 diam.—Busk.

Cucullanidæ.—These parasites are in many respects closely allied to the previous family, but the characters relating to the mouth, coupled with the absence of a true bursa, seem to justify their separation into a distinct family. At all events, it is convenient to consider them apart. In the majority the body is cylindrical, obtusely rounded or truncated in front, and attenuated posteriorly; head broad and globose, in consequence of a strong muscular mass surrounding the pharynx, the latter being usually bivalvular; mouth seldom round, terminal or subterminal, opening vertically or transversely by a slit; tail of the male recurved and slightly coiled, sometimes truncated and usually furnished with membranous winged appendages; a pre-anal sucker occasionally present.

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* The presence of full grown and sexually mature nematodes within the cavities of the heart is of rare occurrence, although these parasites in their embryonic condition (as well as others of the so-called hæmatozoa,) are not unfrequently found in the blood. I have heard it stated that in China dogs frequently perish from nematodes filling up the cavities of the heart, and I have seen one such dog's heart which had burst from over-distension occasioned by their presence. From my recollection of the specimen, I believe the nematodes in question to have been examples of *Spiroptera sanguinolenta.* In the *Journal de Médecine* for 1813, the occurrence of this nematode in the heart of a wolf is described by M. Bohe-Moreau. During my connection with the Edinburgh University Anatomical Museum, I remember to have received an important manuscript bearing on this subject, but I fear the communication has since been lost.

Genera.—*Cucullanus*, Müller; *Angiostoma*, Dujardin; *Dacnitis*, Dujardin; *Pleurorhynchus*, Naudyn; *Ophiostoma*, Rudolphi; = *Proboscidea*, Bruguière; *Rictularia*, Frölich; = *Fissula*, Lamarck; *Hedruris*, Nitzsch; *Synplecta*, Leidy; *Stelmius*, Dujardin.

CHAPTER VII.

ACANTHOCEPHALA.

Acanthocephala or Thorn-headed worms—General characters and distribution—Classification—Organization of *Echinorhynchus anthuris.* Singular mode of egg-formation—Leuckart's researches respecting the development of *Echinorhynchus proteus*—His discovery of the phenomenon of "alternate generation" in this class of parasites.

THE fourth order of helminths, in my arrangement, embraces those species of entozoa commonly known as the Acanthocephala, or Thorn-headed worms. These animals have been variously placed by helminthologists, and I have now departed from the usual plan by associating them with the cestodes to form a third helminthic sub-class entitled *Anenterelmintha.* The grounds on which I have done this have been already fully explained (page 6).

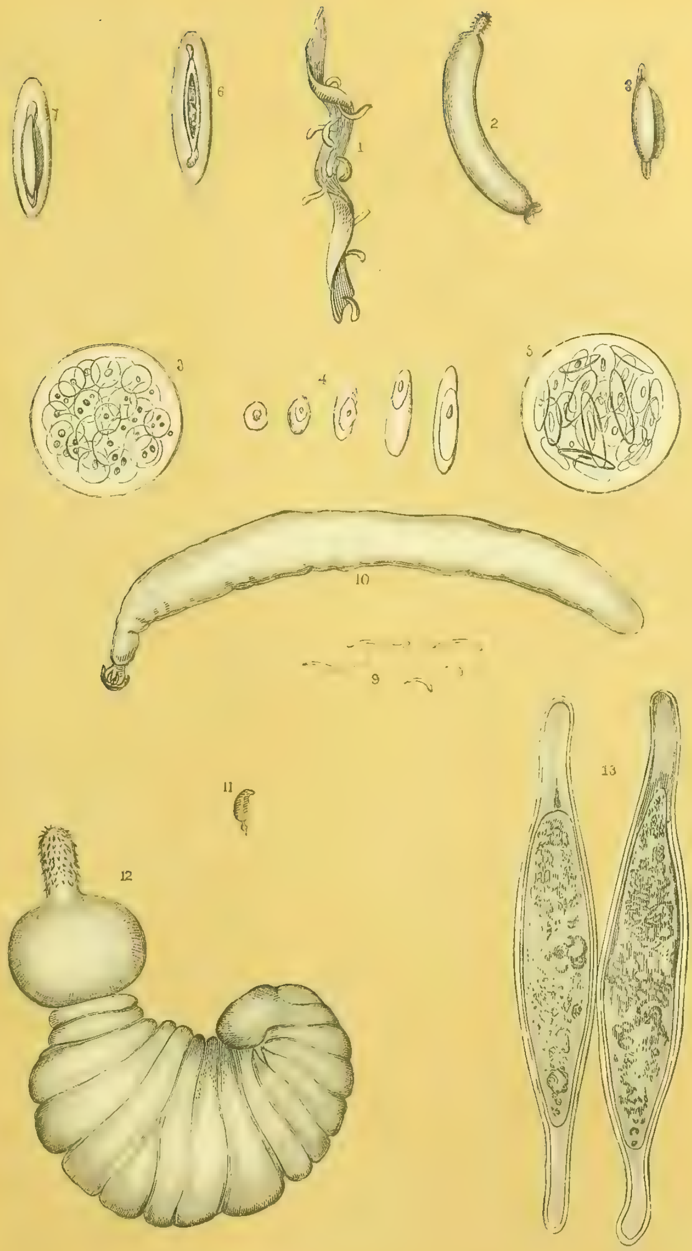
The Acanthocephala are characterised by the possession of elongated, more or less vermiform bodies, often curved upon themselves, and marked by tolerably regular transverse folds (Plate VIII., Figs. 2, 10, 12). They are furnished anteriorly with a retractile proboscis, often termed the head, which is armed with a variable number of recurved hooks disposed in circles at regular intervals. At the point where these rows of hooks cease there is usually a marked constriction or narrower portion of the proboscis which is called the neck, but sometimes this part is even more largely developed than the armed part itself (Fig. 12). As the subclass title indicates, these parasites have neither mouth nor intestine. The sexes are distinct, but during development the species undergo a process of alternate generation.

The Thorn-headed worms are found infesting all classes of vertebrated animals, but up to the present hour none have been discovered in the human body, although one species has been detected in the anthropomorphous Simiadæ. They are especially abundant in birds and fishes; and in the intestines of these vertebrate hosts they anchor themselves to the soft mucous membrane by means of their retractile proboscides. Upwards of one hundred species have been described, and among the more remarkable of these may be mentioned a large species (*E. gigas*) infesting the hog, and another (*E. porrigens*) living in the mysticete whale.

Notwithstanding the great number of Acanthocephala known to exist, the species display a very marked uniformity of character, so much so, that no one has attempted to place them outside the limits of a single genus; consequently, also, all are included in one family. The classification, therefore, stands as follows:—

Ord. ACANTHOCEPHALA=Fam. Echinorhynchidæ=Gen. *Echinorhynchus.*

Echinorhynchus.—To observe the external and internal anatomical peculiarities of this genus, we may select as one of the best and most easily accessible forms, the species which abundantly infests the lesser water-newt (*Lissotriton punctatus*). In the accompanying plate (at fig. 1), I have represented a section of this reptile's intestine of the natural size. It has been laid open in such a manner as to display numerous examples of *Echinorhynchus anthuris;* this parasite being constantly found attached to the internal lining membrane of the gut. A male example, highly magnified, is depicted at fig. 2, and shows at the anterior extremity the partially exserted proboscis, furnished with numerous recurved hooks. At the posterior end there is a peculiar membranous bursa, first described by Dujardin as the terminal pavilion. This appendage only exists in, and is characteristic of, the male, its function being that of an accessary clasping apparatus to facilitate the performance of the sexual act. The intromittent organ itself consists of a simple curved spiculum which is ordinarily concealed from view, and when not in use is lodged in a sheath which opens externally at the point of the tail in the centre of the cup-shaped pavilion. The



Echinorhynchus anthuris Dujardin;
E. angustatus Rudolph; E. nodulosus, Schrank.

G. Busk & T. S. C. del.

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caudal end of the female is smooth and rounded. As in other entozoa, the integument consists of a fine cuticular external membrane, succeeded by a hard, true, fibrous dermis made up of two or more distinct layers. It possesses absorbent powers in a much higher degree than is shared by other kinds of entozoa; for, during life, as observed by Von Siebold, Creplin, Mehlis, and others, these animals are capable of regulating the passage of fluids within and without the body. The integument is succeeded by two muscular layers, one longitudinal and one transverse, the latter being external. If a male example be next laid open, we may notice in the first place the sac of the proboscis lying in the central line immediately below the so-called neck. This forms a dense muscular sheath, which is connected below, or rather held in its place, by three distinct muscular bands, which severally pass from the cœcal end in an outward and downward direction to reach the muscular parietes of the body. The bands in question are termed retractor muscles. On either side of the proboscideal sac there is placed an elongated flattened body, which by some is said to open externally at the base of the neck. The two organs form the so-called lemnisci which Dujardin conjectured might be salivary organs, but which are now more generally regarded as connected with the water-vascular system. At all events, a system of canals containing fluid granular contents occurs in the walls of the lemnisci, and they are, moreover, intimately connected with a similar system of vascular tubes, traversing the general integument of the body. The lemnisci, which are parenchymatous internally, are also supplied with special muscular bands at the outer surface. Below the site of these organs the body is suddenly hollowed out so as to form a large perivisceral cavity, in which we find lodged only such other organs as are concerned in the reproductive process. In the male these consist of two large oval testes placed one above the other in the centre of the cavity, the other being attached to the lower or cœcal end of the proboscideal sac by a strong *ligamentum suspensorium.* Two large and tortuous *vasa deferentia* pass off from the testes in a downward direction, becoming suddenly and enormously dilated to form two large seminal reservoirs, which latter finally communicate below with the sac or sheath of the penis. In the female the reproductive elements are very peculiar; for, in place of a pair of distinct ovaries, we find the general cavity of the body to contain a number of free, well-defined, rounded masses, which develope the eggs within their substance. Two of these egg-bearing masses are shown in the annexed plate (figs. 3 and 5); the former representing an early stage where the organ consists, for the most part, of spherical nucleated vesicles, the latter giving a more advanced stage where some of the vesicles have become much elongated. In fig. 4 the isolated vesicles are seen to display nucleoli as well as nuclei. By further development after their escape from the so-called free ovaries, or egg-bearing masses, these vesicular bodies come to represent, as it were, the several egg-envelopes, so that in a much more advanced egg we have, at length (as in figs. 6, 7, and 8), an outer envelope, a middle covering (which is coloured in at least one species of Echinorhynchus, and probably forms the true shell or chorion), and an internal or third layer. The middle layer is usually constricted at either pole, somewhat after the fashion observed in the egg-shells of Trichocephalus. The third membrane is well shown in the two highly-magnified ova drawn by Mr. Busk (Fig. 13). These are referable to *Echinorhynchus angustatus*. In the advanced eggs of *E. anthuris* I have particularly noticed the lateral disposition of a finely granular mass (figs. 7 and 8), which appears to lie between the true egg-shell and the external envelope. This mass is, therefore, not the yolk itself, but a formative granular mass, similar to that which we find in the nascent ovum of *Tænia solium*. It is, in point of fact, the matrix, part of which is specialised or set aside to form the yolk, whilst the remainder shows itself as a superfluous heap of granules lodged between the outer primitive envelope and the chorion. Possibly the latter may subserve a nutrient purpose.

Development.—Until very recently we were totally ignorant of the changes undergone by the larval Echinorhynchi from their earliest embryonic condition up to the adult state, and what we now know is entirely due to the researches and discoveries of Leuckart. Some few years back, indeed, Dr. Guido Wagener* furnished us with a series of admirable illustrations of the full-grown eggs and embryos of several species of Echinorhynchus, but from the facts then elicited he was erroneously led to conclude that the larvæ passed through their entire course of development in a simple and direct manner. He even conjecturally indicated the presence of lemnisci and digestive organs lodged within the parenchymatous substance of the bodies of the larvæ; the surfaces of the latter being armed throughout with minute, closely-set, and sharply-pointed cutaneous spines. These results were obtained from *Echinorhynchus polymorphus* and *E. filicollis*, and they seemed to confirm the somewhat similar views previously held by Siebold and Dujardin. The notion of a simple metamorphosis, however, has been entirely disproved by Leuckart,† who finds the growth and development of the young to be brought about by the phenomenon of a true alternate generation. This, at least, is the case with *Echinorhynchus proteus*, a species abundant in the Trout and many other fresh-water fishes. The embryo in this last-named species is broad and obliquely truncated at the ventral surface anteriorly, being gradually narrowed to a blunt point posteriorly, and at the front part, on each side of the middle line, there are five or six spines biserially disposed. Similar features are displayed by the embryo of *Echinorhynchus filicollis*. The cortical layer of the body of the embryo of *Echinorhynchus proteus* is made up of a thin cuticle succeeded by a firm dermis, which invests a tolerably uniform mass of contractile parenchyma. The centre of the embryo is occupied by an oval-shaped granular mass, which is altogether free and unconnected with the surrounding contractile tissue. Its nature is not clearly made out, but Von Siebold regarded it as the remains of the yolk. Leuckart, in his experiments, introduced a number of eggs into a vessel of water containing several small crustaceans (*Gammarus Pulex*). These animals readily swallowed the ova, and in a few days the embryos were found emerging from their shells, boring their way through the intestinal walls, passing into the general cavity of the body, and even into the appendages themselves. During the next fourteen days the embryos within the Gammari exhibited an increase of size which became very marked, and at the same time the central granular mass assumed the aspect of cellularity, its spherical outline becoming more clearly defined. In the course of the third week a further metamorphosis occurs. The nuclear mass now rapidly increases in bulk, and by a process of differentiation and grouping of its cell-contents acquires the aspect of a compound organism. It also elongates and eventually assumes the easily recognizable characters of a young Echinorhynchus. Thus, in Leuckart's own words, "the ultimate animal arises in the interior of the primordial body, by a process which presents so close an analogy with the production of an embryo, and, consequently, with the act of generation, that one feels inclined at once to identify it with such an act; and, therefore also, to regard the *Echinorhynchus* as exhibiting an alternation of generation in its mode of development rather than a metamorphosis." The young Echinorhynchus subsequently continues to increase more rapidly in size; its several internal organs, proboscideal sac, and muscular apparatus, gradually coming into view as growth advances. Eventually the young entozoon completely fills the interior of the embryo, the latter having scarcely undergone any change; still remaining, of course, within its crustacean host. What may be regarded as even more extraordinary is the circumstance that the embryonic body next becomes firmly adherent to the young Echinorhynchus, thus ultimately forming, according to Leuckart, the true integumentary envelopes of the adult Echinorhynchus. The original skin of the embryo, however, is cast off "as soon as the Echinorhynchus occupies the whole interior of the embryo." After this, the sexual differences become clearly established, and the now narrowed original space between the surface of the young Echinorhynchus and the body of the embryo becomes transformed into a series of anastomosing canals, constituting the so-called water-vascular system—to which allusion has already been made in my account of the general anatomical features of the adult worm. The lemnisci make their appearance at a late period, and the nature of their connection with aquiferous system is a point which still remains unsolved. Leuckart further remarks that the passage of the young Echinorhynchi into their ultimate piscine hosts is probably unattended with any very striking structural or morphological changes, whilst the metamorphosis of the embryo, as thus far detailed, occupies a period of about six weeks. In general, the crustacean hosts appear to suffer little from the borings of the embryo parasites; but when the latter have assumed the Echinorhynchus condition and happen, at the same time, to be particularly numerous, then they not unfrequently prove fatal to the unsuspecting Gammari. Leuckart informs me that after their transference into the intestine of the ultimate host, a period of about one week more is required to complete their development.

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* Siebold and Kölliker's "Zeitschrift," vol. ix., p. 73, *et seq.*

† "Helminthologische Experimentaluntersuchungen." Gottingen Nachrichten. 1862.

CHAPTER VIII.

CESTODA.

Cestoda or Tapeworms—General characters and habits—Distribution in mammals, birds, reptiles, and fishes—Estimated number of species—Tæniadæ—Particular account of the development of *Cysticercus pisiformis* from the eggs of *Tænia serrata*, and also of the adult tapeworm from the Cysticercus—Constitution of the "zoological individual"—Genera.

The fifth order of Helminths comprises all those familiar forms of anenterate parasites commonly called tapeworms; and I may remark, in passing, that it was Rudolphi who first designated this group Cestoidea (κεστός, a girdle; εἶδος, form), from the characteristic shape displayed by the several species. These animals, therefore, are readily distinguishable by their soft, flat, elongated, semitransparent bodies, which are usually segmented or divided by transverse lines into a number of joints. The anterior or first joint, properly speaking, forms the so-called head. This head is furnished with suckers for the purpose of fixing the parasite to the walls of the intestine of the animal in which it is lodged; the anchorage being often rendered more secure by the development of a special hook-apparatus.

The tapeworm may be looked upon as a creature compounded of a series of partly dissimilar animal forms closely linked in single file; and the welfare of this peculiarly associated colony is, in a great measure, dependent on its connection with the so-called head. On the other hand, viewing the subject philosophically—with due regard to the excellent rule which makes the "zoological individual" to consist of the total products of a single ovum—the entire tapeworm itself is in some cases less than an individual. This, for example, occurs in *Tœnia cœnurus* and *T. echinococcus*, where the single larva produces a number of tapeworms. Ordinarily, however, only a single tapeworm is produced, in which case it may be regarded as the mature individual.

Every cestode passes through several distinct phases during its life-history. In the ordinary colonial or tapeworm condition it has been termed the *strobila* (Van Beneden). The separate joints of which the strobile is composed are denominated *proglottides* or zooids. The anterior segment forms the *head*, and remains barren, those of the neck and front part of the body being sexually immature during the process of strobile-formation. The mature proglottides at the caudal end are capable of realizing an independent existence, and the eggs which they contain develop the six-hooked embryos, or *proscolices* (Van Beneden), in their interior. These latter become metamorphosed into *scolices* or nurses, representing the well-known cysticercal state which, in its sterile or aborted condition, forms the common *hydatid*.

Habits.—During the greater part of their life-period the cestodes are parasitic animals, the mature proglottides and eggs being free only during a certain interval of time. The cestode entozoa, like the trematodes, frequently change their residence either in an active or passive manner; their transmigrations being absolutely necessary for the propagation and continuance of the species. The cestodes are bisexual, and all of them exhibit the phenomena of alternate generation. Details of these genetic changes and wanderings will be more fully described hereafter.

Distribution.—Mammalia.—If we except their feeble prevalence among the reptiles, the cestode parasites are pretty uniformly distributed throughout the vertebrate division of the animal kingdom. In their larval or cysticercal state they are especially abundant in mammals, whilst the mature tapeworm-forms are scarcely less frequent in occurrence. The human body alone is liable to be invaded by ten species of tapeworm, but, save in the cysticercal state, they do not appear to be very prevalent in the quadrumanous tribes. The *Cysticercus tenuicollis* is tolerably constant in the higher monkeys, and four distinct tapeworms have been found in the Barbary ape (*Inuus*). The lemurs also harbour various Cysticerci, and I have discovered a singular form of *Cœnurus* in the lungs and liver of the common Madagascar species. Only a few species of tapeworm have been noticed in Cheiroptera, and in the Insectivora they are scarcely more abundant. In the true Carnivora they are plentiful, and more particularly so in our domesticated dogs. In the vegetable-feeding rodents the cestodes are by no means uncommon, whilst those animals which partake of a mixed diet, such as rats and mice, are still more liable to invasion. Hitherto, no tapeworm appears to have been detected amongst the edentulous mammals. The larger pachyderms and solidungulates harbour a few adult forms, but only the larvæ appear to be known in swine; a true Tænia, however, has been described as occurring in the aberrant genus Hyrax. The typical ruminants are almost constantly infested both by mature and immature forms, but in the camels larvæ only have been detected. One or two species are known to infest seals, and the same may be said of Cetacea; the common porpoise harbouring an unusually large form (*Diphyllobothrium stemmacephalum*). In the marsupial mammals the cestode parasites are comparatively rare.

Birds.—Contrary to general expectation, the cestode entozoa appear to be quite as abundant in the granivorous birds as they are in the carnivorous hawks, owls, and buzzards. As yet, indeed, we have no certain knowledge of their occurrence in the family of vultures; a circumstance arising probably from the few opportunities we have had for examining these birds in their wild state. Cestodes abound in the woodpeckers, pigeons, partridges, pheasants, barn-fowls, and their allies, and they are scarcely less common in the bustards, emews, and ostriches. In the herons, plovers, ducks, divers, gulls, and water-birds generally, the adult tapeworms are extremely abundant, whilst their larvæ are to be sought for amongst the fishes, molluscs, and other aquatic animals on which these feathered tribes feed.

Reptiles.—As before hinted the cestodes are notoriously scarce in all the reptilian vertebrates, even in the salamanders and batrachians, where many other kinds of entozoa are uniformly present. Not a single cestode occurs either in the common or in the esculent frog, and only one species has been detected in the toad. None are yet known to infest the crocodiles and tortoises, but one species has been found in the common turtle. The cestodes are almost entirely unrepresented in the lizards, and only a few forms have been discovered in the curious amphisbænæ and ophidians.

Fishes.—A great variety both of adult and larval cestodes take up their residence in piscine "hosts." Usually such tapeworms display characters very distinctive from those inhabiting birds and mammals, being commonly furnished with special tentacular hook-appendages employed as supplementary organs of boring and anchorage. In the cartilaginous sharks and rays these cestodes are remarkably abundant, and in certain osseous species they are scarcely less frequent. The only noteworthy kinds of fish which, so far as our present knowledge extends, seem to be free from the invasion of tapeworms are the sturgeons, blennies, gobios, mullets, sparoids, and Sciænidæ.

Comparatively few of the invertebrata appear to harbour the cestode entozoa in their adult condition, but to this rule the cuttle-fishes form a noted exception. These singular animals also harbour a great variety of tapeworm-larvæ, forming one of the chief sources whence the sharks and rays obtain the same parasites destined to arrive at sexual maturity within their own bodies. Probably no inconsiderable number of tapeworm-larvæ abound in aquatic molluscs, insects, and other invertebrate groups, but at present we are only acquainted with a few distinct forms, the majority of which are entertained by jelly-fishes.

Number.—It is almost as difficult to estimate the number of true cestode species at present in existence, as it is to compute the numerical strength of the flukes and roundworms. Upwards of two hundred and fifty distinct forms have been described, but it may be doubted if two hundred of these are really good species. Assuming the latter to represent their number, the following simple table of classification will conveniently embrace all the species :—

Cestoda { *Tæniadæ* (Family I.)
Bothriocephalidæ (Family II.)
Tetrarhynchidæ (Family III.) }

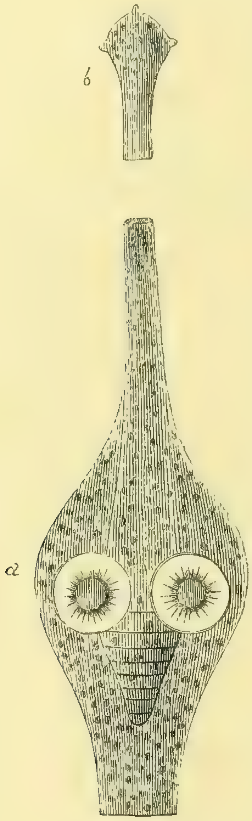

Fig. 24.—Head of Tænia paradoxa, *Rudolphi;* from the intestine of an oyster-catcher (*Hæmatopus ostrealegus,* L.); *a,* with the rostellum partly invaginated; *b,* end of the rostellum expanded; × 260 diam.—Original.

Tæniadæ.—The true tapeworms are characterised by the possession of a small distinct head furnished with four simple oval or round suctorial disks (suckers), and commonly also with a more or less strongly-pronounced rostellum (proboscis) placed at the summit in the median line. This prominence, when largely developed, becomes retractile, and when not in use is lodged within a flask-shaped cavity, lined by a sheath and supplied with special muscles; it is also very frequently armed with a single or double crown of horny chitinous hooks, there being, occasionally, as many as five or six separate circular rows of these organs. Attention to the number, relative size, and disposition of the hooks is often sufficient to determine the particular species. In nearly all cases, the reproductive orifices are situated at or near the margins of the joints, which are bisexual.

Development.—As a tolerably minute account of the anatomy of the Tæniadæ will subsequently appear in my special account of the structure of the common tapeworm infesting man, I at once proceed to select a cestode from the lower animals in order to afford a clear conception of the life-changes and developmental phenomena displayed by this singular group of animals—in common, of course, with the other closely-allied families referable to the same order.

In this view I take one of the six species known to infest the dog, namely, the *Tænia serrata* of Goeze. This worm, in its adult state, acquires a length of four feet and upwards, whilst its greatest breadth is scarcely the fourth of an inch. The head is oblong in shape, surmounted by a short and thick rostellum, the latter being surrounded by a double crown of hooks, forty-eight in number, that is, twenty-four in each row. The mature joints are trapezoidal; having, however, the inferior angles sufficiently prominent to produce, collectively, the characteristic serrated margin of the worm. The reproductive papillæ occur at the centre of the lateral line of each joint, being disposed in an irregularly alternate manner throughout the series.

When, as Leuckart first pointed out, several of the mature joints (proglottides) are detached from the body of a *Tænia serrata*, and are administered to a young rabbit, we do not—upon subsequently killing and dissecting it—detect with the naked eye any structural changes within the body of the animal, although several days may have elapsed since the worm-feeding took place; but if a microscopic examination of the rabbit's blood (from the great portal and other abdominal veins) be made only twenty-four hours after the time of administration, the fluid will be found to contain a great number of minute cestode embryos. On further examination these minute hæmatozoa will be found to be armed with hooks for boring, and to correspond in size with the ova of *T. serrata*, constituting the so-called six-hooked brood of this tapeworm. About the fourth day small, white, semitransparent vesicles, averaging the $\frac{1}{80}$ of an inch in diameter, make their appearance in the liver, each of them containing within its interior a little embryo, measuring about the $\frac{1}{800}$ of an inch in length. These embryos are the same as those detected in the blood, and though not actually seen in the act of migrating, have evidently bored their way through the walls of the vessels into the cell-tissue of the organ. At the fifth day the size of the vesicles has sensibly increased ($\frac{1}{40}$ inch), and they now display an oval figure; their growth becomes exceedingly rapid, and by the sixth day they measure the $\frac{1}{25}$ of an inch longitudinally. This growth continues to advance, so that at the commencement of the second week, *i.e.*, eight days after the worm-feeding, the liver of the rabbit presents a more or less uniformly spotted appearance, conspicuously visible to the naked eye.

At the beginning of the third week—supposing one of our experimental animals to have been destroyed at this period—the liver spots are found to be considerably enlarged, especially lengthwise, one end of the cyst becoming narrow and pointed whilst the other is still rounded. Later, in the third week, this elongation becomes more striking, most of the vesicles also displaying curves and undulations, which become so extended that the cysts by and by acquire the form of long channels. At the fourth week many of them will be found to have run into one another, producing here and there a more or less regularly-branched appearance.

All these phenomena, as they occur in the liver, are undoubtedly due to the active migrations and growth of the six-hooked embryos, and in the earlier stages Leuckart has found distinct evidences of the existence of the six-hooked boring apparatus within the contents of the vesicles. Stein has also observed them from another species of tapeworm. It was not to be wondered at that difficulties would be encountered in determining with certainty the connection between the six-hooked hæmatozoa and the liver vesicles, because, very soon or immediately after the passage of the former (embryos) out of the blood into the liver-parenchyma, they appear to commence the metamorphosis by which the six-hooked embryo is transformed into a true cysticercus. The liver vesicles, in their later stages of growth, are, in point of fact, young cysticerci enclosed in capsules of connective tissue, formed by the liver, as it were, in self-defence. The six-hooked embryos, whilst still in the blood, may be said to wander "passively;" but, in the first instance, they must have passed "actively" into the vessels of the intestinal villi after escaping from their egg-coverings. Carried by the circulating current into different parts of the body, they again appear to exercise their boring propensities in that particular and suitable locality (liver) which a certain appetite, so to speak, instinctively induces them to select.

Before tracing onward their further progress, I may revert to the state of things observable at the third week. At this period the partially metamorphosed embryos are about one line in length, and they have acquired a structureless epidermis, in addition to two special sub-dermal layers of muscular fibre. At this time also there arises, from the development of nucleated cells, a turbid appearance at the anterior end of the embryo. This condensation of the parenchyma is destined to form the head of the so-called *Cysticercus pisiformis*. A folding inwards of the epidermis at the anterior end of the embryo forms what is called the "cephalic pit;" an opening being thus left at the centre of the point of inversion. Subsequently, the little embryo displays more marked differentiations of structure, and the turbid mass shows two divisions—an outer limiting line forming the "receptaculum capitis," and an inner one encircling the "central cephalic mass." Traces of a skin-skeleton under the form of "calcareous particles" also make their appearance in the substance of the receptaculum, becoming extremely abundant in this situation at a still later period. Formerly these calcareous corpuscles were regarded as morbid formations, but the view above taken has now gained very general acceptance. Contemporaneously with the formation of the corpuscles, Leuckart also found vessels between the muscular and epidermic layers; these vessels are said to contain a clear, limpid fluid, circulated by means of cilia.

It should be noted that only a certain proportion of the little vesicles (which at first appear so numerously scattered throughout the substance of the rabbit's liver) pass through the developmental changes above described. This would seem to be owing either to their being originally too numerous to admit of their growth within the infested organ, or, as Kuchenmeister observes, "they do not find a favourable soil for their further development." After the lapse of fourteen or fifteen days the aborting vesicles commence a kind of retrograde metamorphosis, passing, he adds, "to the state of caseous, granular, tubercular, or atheromatose masses, in which we may generally seek in vain for any remains of the embryo." These appearances are familiar to all helminthologists.

From Leuckart's researches it would seem that towards the close of the third or beginning of the fourth week, some of the young cysticercs make their escape into the abdominal cavity of the rabbit; in this case, remaining enveloped in their cysts of connective tissue, and pushing the peritoneal covering of the liver before them. In this condition we often find them loosely suspended in the abdominal cavity. Others escape in a more advanced state (at the fifth and sixth week); they are independent of their cystic envelope, and may be found wandering over all parts of the abdomen. By this time these "wandering larvæ" have attained a length of several lines, but if examined microscopically the head will still be found to be imperfectly formed. Their perfect cysticercal state is acquired only after undergoing a second process of encystation, which is usually completed at the expiration of eight weeks.

The various parts of the head successively appear after the same fashion as the head itself. Cloudy masses of closely aggregated cellules collect here and there, *i.e.*, in places specially destined to develop the suckers, the coronet of hooks, and other parts. The *receptaculum capitis* becomes thinned out and displaced by the neck and folds of the (subsequent) body, both of which regions make their appearance whilst the head is yet enclosed in the receptaculum. The head afterwards becomes included within the folds of the body, and the whole mass is eventually protruded from the surrounding caudal vesicle, at the pleasure of the animal. At this period of their complete development, the Cysticerci begin to degenerate and calcify, when not transferred to their proper final "host."

It has been abundantly proved that the administration of Cysticerci which have only arrived at their wandering (imperfect larval) condition will produce only negative results, whilst those which have undergone a second encystation—or, in other words, are eight weeks old—will, in the intestine of their appropriate final host, readily develop into the *Tænia serrata.** If the mature larvæ are enclosed in stout investing capsules at the time of their passive introduction into the dog's stomach, several hours may elapse before the cysts will be digested; but, if the envelopes be thin, two or three hours will suffice, not only to remove the adventitious coverings, but also to destroy the caudal vesicle of the Cys-

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* I have administered to dogs upwards of thirty fresh *immature* specimens of *Cysticercus pisiformis,* in five separate worm-feedings, but in no case have these larvæ been able to undergo further development. On the other hand, I have, on four occasions, fed dogs with several *mature* examples of the same Cysticercus, and in every instance I have succeeded in procuring the *Tænia serrata.* In one instance only was there any doubt in my mind as to the success of the breeding-experiment.—T. S. C.

ticercus itself. According to Leuckart, remnants of the caudal vesicle may be seen after the expiration of an entire day. After this, the young tapeworm grows rapidly, and on the second and third days it displays well-marked indications of segmentation. It has now acquired the length of half an inch or more, and at the twelfth day is fully four inches long. Considerable variation in length, however, is not unfrequent, partly owing to the circumstances above mentioned, and partly to the degree of contraction or extension of the body of the worm itself. So far as my observation extends, the joints become sexually mature about the twentieth day, but I believe this condition may take place at an earlier period.

The facts above recorded in relation to the development of *Tænia serrata* from *Cysticercus pisiformis* are principally due to the investigations of Leuckart; but the experiences of Kuchenmeister, Van Beneden, Eschricht, Haubner, Röll, Müller, and others, confirm, in various ways, the correctness of the data here set forth. My own experiments have produced very similar results; and if they have done nothing else, they have, at least, satisfied me that Von Siebold's opposition to the generally-received opinion—as to *T. serrata* being quite distinct from *T. cœnurus*, *T. solium*, and *T. crassicollis*—is altogether a mistake. The same may be said in regard to the still more recent doubts thrown upon this subject by the honestly-conducted inquiries of MM. Pouchet and Verrier, who, however, have not been able to set aside the explanations offered by Van Beneden as to the circumstances which prevented their arriving at a satisfactory result. Without any hesitation, it may be truly affirmed that the developmental phenomena above recorded, are, in the main, absolutely correct, and, therefore, before quitting this subject, I am induced to offer, as it were, a recapitulation of the facts, in the form of a synoptical table. The phases of existence in the life-cycle of *Tænia serrata* may, I think, be usefully expressed in the following manner:—

ZOOLOGICAL INDIVIDUAL

ZOOLOGICAL INDIVIDUAL	*a.* Ovum in all stages. *b.* Six-hooked embryo = boring larva (T.S.C.) = *proscolex* (Van Beneden) *c.* Resting larva (T.S.C.) = *Cysticercus pisiformis* = *scolex* (Van Beneden) *d.* Immature tapeworm in all stages.	protozooid (Huxley).
	e. *Tænia serrata* = sexually mature tapeworm colony = *strobila.*	
	f. *Proglottis* = free-joint or segment = deutero-zooid (Huxley).	

Genera.—*Tænia*, Linneus; = *Alyselminthus*, Zeder; = *Halysis*, Zeder; = *Rhytelminthus*, Olfers; = *Thysanosoma*, Diesing; = (in the larval state) *Cysticercus*, Rudolphi; = *Hydra*, Linneus; = *Vesicara*, Schrank; = *Hydatigena*, Goeze; = *Hydatula*, Viborg; = *Hydatis*, Lamarck; = *Finna*, Werner; = *Piestocystis*, Diesing; = *Cœnurus*, Rudolphi; = *Polycephalus*, Zeder; = *Echinococcus*, Rudolphi; *Sciadocephalus*, Diesing; *Ephedrocephalus*, Diesing; *Amphoteromorphus*, Diesing; *Peltidocotyle*, Diesing; *Caryophyllæus*, Gmelin; = *Phylline*, Abildgaard; = *Caryophyllinus*, Schrank; *Diplacanthus*, Weinland; *Acanthotrias*, Weinland; *Hymenolopis*, Weinland; *Tæniarhynchus*, Weinland; *Echinococcifer*, Weinland; *Proteocephalus*, Weinland; *Dipylidium*, Leuckart.

CHAPTER IX.

CESTODA.

Particular larvæ—*Cœnurus cerebralis* of the sheep—Rose's discovery of a second kind of Cœnurus—Several other forms now known—Numan's observations—The *Cysticercus tenuicollis* and *C. fasciolaris*—Bothriocephalidæ—Structure and development—Genera—*Diphyllobothrium* and *Tricuspidaria*—Tetrarhynchidæ—Structure, habits and development—Genera.

In the main, it may be said, the course of development is pretty much the same in all tapeworms, and yet there are certain larval forms, such as Echinococcus and Cœnurus, which instead of separately developing into single tapeworms, become, as it were, the immediate progenitors of a great number of tapeworms. In these cases, the product of a single ovum will embrace not only the life-phases above indicated, but an almost indefinite multiplication of the same. In the case of Echinococcus, the zoological individual will comprise several thousand tapeworms, whilst in the case of Cœnurus it will include, at least, several hundred. If all the tapeworms thus proliferated from a common hydatid could remain attached to the larval stock, then we should have an animal form strictly comparable to a compound polyp; each polyp, in this case, would be a kind of secondary individual (strobila) made up of an almost indefinite number of tertiary individuals (proglottides). The development of Echinococcus will be described in detail hereafter, but some further account of its congener is here desirable.

Cœnurus.—This title was originally given by Rudolphi to the well-known hydatid so common in the brain of the sheep, and which produces in that animal the disease termed the "staggers."

This malady has likewise been called sturdy, turnsick, goggles, and vertigo. The Cœnurus, as previously stated, is now known to be the larva of a species of tapeworm (*Tænia cœnurus*) infesting the dog. At an early date it had been described by Gmelin and Gœze as a Tænia (*T. cerebralis* of the former and *T. vesicularis* of the latter). Until recently it was supposed that this kind of cestode larva only inhabited the brain, being also confined to the *herbivora.* I have, nevertheless, discovered another kind of Cœnurus, infesting the lungs and liver of a Madagascar Lemur, occasioning this animal's death by atrophy of the organs, and consequent denutrition of the entire body. Mr. Rose had likewise previously discovered a Cœnurus beneath the skin of the rabbit.

The brain-hydatid of the sheep, as commonly met with, varies in size from a pea to a pigeon's egg, but occasionally it exceeds this bulk, and (when it happens to occupy the spinal canal) may acquire a length of upwards of a foot.* Ordinarily, it is a simple bladder-like vesicle, distended by a clear, pale-yellow, albuminous secretion, displaying on its outer surface a great number of retractile papillæ. These small elevations, when microscopically examined, are found to be tapeworm heads connected by narrow stalks to the common vesicle supporting the colony. The stalks, in fact, are short, cylindrical tapeworm-bodies, their transverse markings representing a series of future proglottides in their most rudimentary form. Protruded to their fullest extent, these young tapeworms (scolices) measure fully $\frac{1}{6}$ of an inch in length, the transverse diameter of the head being about $\frac{1}{18}$ of an inch. When highly magnified the conical heads exhibit a prominent, pointed rostellum, armed with a double coronet of hooks, and four large suckers situated at the equatorial margin immediately beneath. The coronet is made up of two sets of hooks which may be easily distinguished by their size, and also by the circumstance that they regularly alternate with one another, fifteen in each row. The integument consists of a fine external pellicle enclosing a soft granular dermis, and subdermal parenchyma, in which we detect an immense multitude of the so-called calcareous corpuscles. The great vesicle itself shows a very different structure, being made up of six or eight layers of regularly-disposed cells, in which neither vessels nor corpuscles can be recognized. According to Numan, both crystals and larvæ are found in the fluid of the sac, but I fear they must be regarded as pathological formations.

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* Leuckart informs me that he has an example of this kind in his private collection. Numan describes and figures a similar specimen in his elaborate monograph, "Over den veelkop-blaasworm der hersenen." Plate iv. fig. 1.

Besides infesting cattle and sheep, the common Cœnurus has been found in the goat, in the horse, in various species of antelopes and deer, in the dromedary, and also, it is said, in the rabbit. In most of these animals it is liable to give rise to a formidable disease, the symptoms of which are found to vary considerably according to the particular situation occupied by the parasite, whether in the brain or spinal cord. In the sheep the disease is recognized at first by a heavy, stupid, wandering gait, which is frequently succeeded by irregular, tortuous, whirling movements of the body, accompanied with convulsions. A simple temporary cure is readily effected by puncturing the head over the diseased part, but very commonly the animals die of exhaustion and inability to take their proper amount of food. In the later stages of the disease, especially where several Cœnuri exist in the same brain, it is not uncommon to find the skull of the sheep thinned out in various directions. In many places the bony absorption is complete, so that the skull exhibits, on being dried, a perforated and irregularly honeycombed appearance.

The administration of fresh Cœnuri to dogs has proved the source whence these larvæ are derived, whilst, on the other hand, the feeding of lambs with a particular species of tapeworm has demonstrated whence the Tæniæ are derived. Kuchenmeister, Haubner, Gurlt, Röll, Eschricht, Leuckart, Van Beneden, and others abroad, have repeatedly shown that the Cœnurus of the sheep is the larva of the *Tænia cœnurus* normally infesting the dog, and their researches have, I believe, been confirmed in our own country by Mr. John Gamgee. Be that as it may, sheep fed with the proglottides of *Tænia cœnurus* get Cœnuri in their brains, and dogs fed with the latter get the former developed in their intestines.

The Cœnuri which I obtained (December 30, 1857) from the

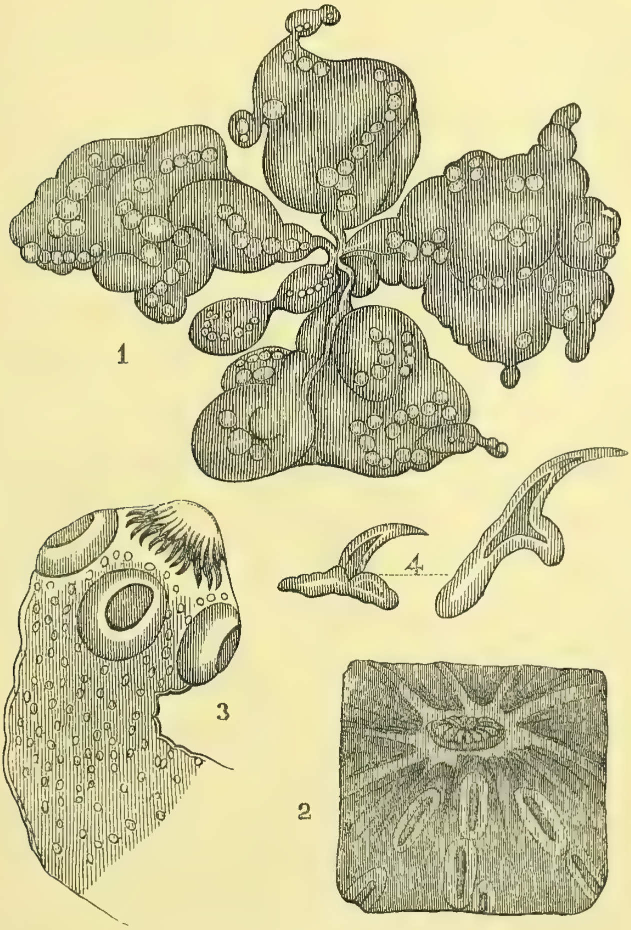

Fig. 25.—*Cœnurus;* from a Ring-tailed Lemur (*Lemur maco*); 1, a colony (natural size); 2, section of a small lobule (× 20 diam.); 3, scolex, or future tapeworm-head (× 40 diam.); 4, hooks (× 260 diam.).—Original.

ring-tailed Lemur of Madagascar are clearly referable to another species of tapeworm, which is probably altogether unknown to science. They occurred in great numbers throughout the substance of the liver, and more particularly, also, in the lungs on both sides of the chest. Many loose and detached specimens also existed in the cavity of the right pleura. The majority of those occupying the chest were loosely connected to the pleura, and presented the form of vesicular, semi-transparent bodies, varying in size from a filbert to a large walnut; many being united together in bundles so as to form complex masses four or five times larger. One of these masses is here drawn (fig. 25, p. 119). It consists of four large Cœnuri, their combined pedicles forming a single stalk which was found attached to the lining membrane of the right lung. A fifth, hourglass-shaped rudimentary Cœnurus is also visible. Every Cœnurus supports a variable number of lobules, each of which latter supports one or more rounded eminences or papillæ of tolerably uniform size. Here and there the papillæ resemble chains of beads. No trace of any tapeworm heads could be seen with the pocket-lens, but on detaching the rudimentary Cœnurus, and placing it under a half-inch objective, I found certain of the papillæ to be nearly flat, and to present oval depressions at the surface (2, fig. 25). In these instances the little eminences had been folded inwards so as to project into the cavity of the larva. At the point where the peduncle joined the stalks of the other Cœnuri the membrane was folded in a stellate manner. A distinct pellucid cuticle and granular dermis were the only structures visible at the smooth parts of the vesicle, but on examining the larger papillæ they were found to consist of several membranous layers folded one within the other. These were carefully dissected with the aid of needles, and each one, so examined, displayed in the centre of the folds a well-formed tapeworm-head with four characteristic suckers, and a prominent rostellum supporting a double coronet of hooks; thirty-two of the latter in all (3, fig. 25). The two rows displayed a very marked disparity in respect of the size of the individual hooks, their relative differences in form being equally conspicuous. Each hook showed a distinct anterior and posterior root, and a central granular, apparently non-chitinous matrix (4, fig. 25). The head, neck, and folds of the body were abundantly supplied with the so-called calcareous corpuscles. The interior of each vesicle was filled with a pale yellow albuminous fluid, in which neither crystals nor free scolices were visible.

In this connection it is only right that I should mention that so early as the year 1833, Mr. Caleb Burrell Rose, formerly of Swaffham, Norfolk, discovered an undoubted example of polycephalous hydatid or *Cœnurus* in the rabbit; the parasite in question bearing a very close resemblance to the example above described. As the accuracy of Rose's determination respecting the characters of the hydatid has been called in question, I particularly invite attention to the original description as recorded in the "London Medical Gazette" for November 9th, 1833. At page 206, vol. xiii. of this periodical, after describing the common *Cœnurus cerebralis* of the sheep, Rose writes as follows:—"This (*i. e., C. cerebralis*) is the only species of Cœnurus noticed by authors, but I have met with another. It infests the rabbit, and I have found it situated between the muscles of the loins. It is also met with in the neck and back. This hydatid grows rapidly, and multiplies prodigiously, and being seated near the surface, it soon projects, and sometimes forms a tumour of considerable magnitude. When the warrener meets with a rabbit thus affected, he punctures the tumour, squeezes out the fluid, and sends the animal to market with its brethren. I possess a specimen of this species in a pregnant state. The earliest visible state of gestation is a minute spot, more transparent than the surrounding coats of the parent; this enlarges till it projects from the parietes of the maternal vesicle. It continues to enlarge until it becomes a perfect hydatid, attached by a slender peduncle only; even whilst small, other young are seen sprouting from it, and so on in a series of three or four. My specimen exhibits them in every stage of growth, from a minute point to a vesicle the size of a hen's egg. As I can see no difference in structure between this hydatid and the last-mentioned (*i. e., Cœnurus cerebralis*), I am unwilling to consider it a different species; for surely a varying locality ought not to constitute a specific character."

From Rose's careful description it would seem impossible to deny that we here have to deal with a genuine Cœnurus; nevertheless, as I have said, the accuracy of his conclusions has been doubted. Guided by the light of modern discovery, the only objections which can reasonably be made to the inferences drawn by Rose are such as have reference to the structure and functions of the different parts of the hydatid. Thus the terms "pregnant" and "gestation" are inapplicable, seeing that the young scolices are developed by the now well-understood non-sexual process of budding. In a second communication on the same subject ("London Medical Gazette," 1844, vol. xxxiv., p. 526), Rose described another example of the same kind of hydatid, but he still refrained from giving the entozoon a distinctive name. Curiously enough, however, the author, who has obligingly forwarded me a drawing of the parasite, which enables me to speak very positively as to its distinctiveness, had named it *Cœnurus cuniculi* in his MS. notes of one of the original dissections. The illustration in my possession bears a close resemblance to other specimens of *Cœnurus* (at present undescribed) which I have in my collection, and which were obtained from an American Squirrel. So far as my observations have been carried, I have little doubt that Rose's Cœnurus from the rabbit and my Cœnurus from the Lemur are the larval representatives of two totally distinct species of Tænia. As regards the third form (from the Squirrel) I cannot speak with equal confidence, but I hope ere long to solve the problem. When Leuckart spoke of my lemurine Cœnurus as a parasite of considerable interest, it is probable that he had no knowledge of Rose's early discovery respecting the existence of a similar larval type in the rabbit.*

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* See his "Bericht," in Wiegman's "Archiv" for 1860, p. 139. In this admirable *résumé*, however, Leuckart mentions the case of Baillet, who more lately found a Cœnurus embedded in the pectoral muscle of a rabbit, and he also refers to the statements of Eichler, who has recorded the occurrence of a Cœnurus in the subcutaneous cellular tissue of a sheep. In Eichler's case the hydatid was about the size of a goose egg, and displayed nearly 2000 heads. I should think it rather unlikely that these polycephalous larvæ could be referred to the so-called *Cœnurus cerebralis.*—T. S. C.

The observations of Rose, however, had not altogether escaped the notice of Continental helminthologists, for I find the well-known Dutch author, Numan (in a foot-note to his Memoir, entitled “Over den veelkop-blaasworm der Hersenen”), making the following observations :—“Rose observes that he has found Cœnurus in bladdery rabbits (blaaszieke konijnen) in the skin, and in the cellular tissues of the trunk and extremities. The veterinary surgeon, Engelmeyer, of Burgau, says he has also found the *Cœnurus* (Veelkop) in the liver of a cat (“Thierärztliche Wochenschrift van 1850,” s. 192). These observations differ thus far from those of other writers, according to whom the Cœnurus is only found in the brain and spinal marrow. However, it is not impossible in particular cases that some parasites may have strayed from their ordinary dwelling-places.” Numan seems to have been not a little puzzled to account for these discrepancies, and he was altogether undecided regarding the mode of propagation of Cœnuri and Cysticerci, as will be gathered from the passage quoted below.*

Cysticercus.—I have already described in detail the transformation of the larva known as *Cysticercus pisiformis* into the *Tœnia serrata*, but there are two other forms which specially demand a passing notice. These are the *Cysticercus tenuicollis* and *C. fasciolaris.* The former is the larval condition of the *Tœnia marginata*, infesting the dog and wolf; the latter being the scolex of the *Tœnia crassicollis*, inhabiting cats.

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* “Ik moet het onbeslist laten, of de grondbeginsels, waaruit de wormen uit de blaas ontspruiten, als wezenlijke of als zoogenaamde kiemen (*gemmæ*) zijn te houden, waaromtrent de gevoelens der voornamste Natuuronderzoekers, die zich met de nasporing der blaaswormen hebben onledig gehouden, nog uiteenloopen. Gulliver door Rose (a. p. pag. 231) aangehaald, houdt ze voor eijeren, in den *Cysticercus tenuicollis*, en Goodsir, mede aldaar genoemd, spreekt ook van *ova* bij den *Cœnurus cerebralis*; doch de laatstgenoemde en Busk houden ze voor *gemmæ.* Hier wordt voots gewezen op Owen en de meeste onderzoekers van den tegenwoordigen tijd, die het daarvoor houden, dat alle hydatiden zich alleen door *gemmæ* reproduceren. Rose merkt voorts aan, dat, hetzij men de geboorte dezer ingewandswormen toekenne aan eijeren of kiemen (*gemmæ*), dit om het even is, wat hunne verspreiding (*dissemination*) betreft, daar zij ingesloten zijn, waardoor de wijze, hoe zij naar buiten komen en verspried worden, tot dusver een gesloten boek is.”

The *Cysticercus tenuicollis* enjoys an unusually wide distribution, for in addition to its occasional presence in man, it has likewise been found in various monkeys, in cattle and sheep, in several other ruminants, in horses, in swine, and, it is said, in squirrels. Ordinarily, this larva acquires the size of a pigeon's egg, but in certain cases the caudal vesicle attains the bulk of a cricket-ball. Sometimes the vesicle is perfectly spherical, at other times it is elongated and pyriform. The head is furnished with a double crown of hooks, and is succeeded by a short filiform neck which expands more or less suddenly into a tolerably thick body, marked by numerous fine transverse lines. The transition from the lower part of the body into the caudal vesicle is occasionally very sudden, and at other times very gradual. I have found a remarkable example of the former kind, where the parasite was lodged in the abdomen of a Wart Hog (*Phacochœrus æthiopicus*), and a scarcely less remarkable illustration of the latter in a Red River Hog (*Potamochœrus penicillatus*). In the last-named animal one larva occupied a cyst in the liver, four others being attached to the mesenteric folds of the peritoneum. All five bore a close resemblance to one another, but they differed very materially from the Cysticercus infesting the Æthiopian Wart Hog.

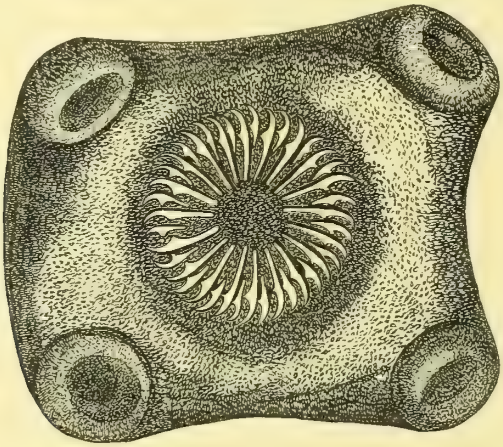

Fig. 26.—Head of *Cysticercus pisiformis* (× 50 diam.); from the rabbit.—Drawn from a photograph taken by Dr. Hallifax.

Those attached to the mesentery were also encysted ; but in these instances the envelope appeared to be merely a production of the peritoneal membrane itself, and not an abnormal product, such as had clearly resulted from inflammatory action both in the case of the liver-cyst and in the fibrous capsule of the *Cysticercus* from the Wart Hog. The Cysticerci of the Red River Hog, when withdrawn from their enveloping membranes, exhibited a more or less oval or elliptic outline ; but the drawing here given (fig. 27) shows only the neck (*a*), the body (*b*), and part of the largely developed caudal vesicle (*d*). The head, being inverted and enclosed within the upper part of the neck, could only be found after a prolonged dissection and unfolding of the parts. When this was done, and the head placed under an inch objective, it was found to display the usual four sucking disks, and a double coronet of hooks. The margin of the neck was bordered by a double contour, the parenchymatous substance being everywhere studded with a multitude of calcareous corpuscles, which were not limited to the neck itself, but were also present in the head. To these structures I shall again have occasion to allude, but in the meantime I only take notice of the body and caudal vesicle of our Cysticercus. The former was about half an inch long, and somewhat

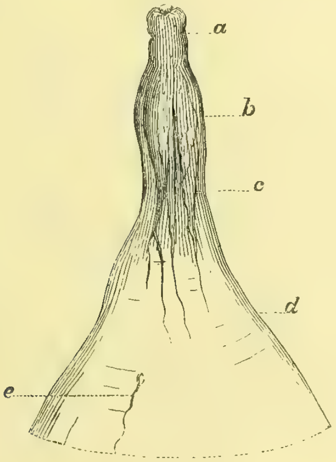

Fig. 27.—Upper part of *Cysticercus tenuicollis ;* from the Red River Hog (*Potamochœrus penicillatus*) ; natural size.—Original.

distended by the presence of soft, irregular bundles of tissue in its interior. This tissue occurred in the form of shreds or rope-like coils (*c*, fig. 27), which became finely attenuated below, depending loosely into the cavity of the caudal vesicle. Histologically, these shreds merely consisted of a fine granular matter, and therefore were not referable to any specialized structure or set of organs. Neither the body nor the vesicle exhibited the transverse striæ seen in the Cysticercus from the Wart Hog; but in addition to a few irregular surface-foldings, the lining membrane of the vesicle gave off here and there some extremely delicate thread-like filaments, having the same structural character as those bundles of granular parenchyma just described. Little circular spots (*e*) marked their origin; and from these points they were suspended in the fluid contents of the vesicle.

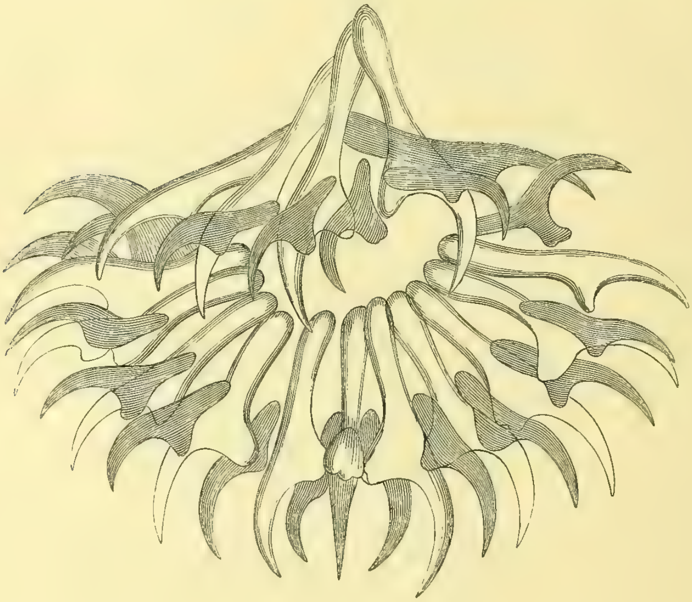

Fig. 28.—Crown of hooks from the *Cysticercus fasciolaris* of the mouse; highly magnified.—Busk.

The *Cysticercus fasciolaris* found in the liver of rats and mice presents a very different appearance to the above. Here, the caudal vesicle is generally reduced to the size of a pea, or is very much smaller, sometimes being scarcely visible. Whilst the scolex is still within the mouse the larva frequently assumes the tænioid condition; but in all such cases, the incomplete development of the sexual organs shows that the parasite is still a larva, and has not yet gained access to its proper ultimate host. In most Cysticerci there is usually no trace whatever of the future reproductive apparatus of the tapeworm.

Amongst the few other cestode larvæ which have been satisfactorily traced to their adult strobila condition, I need here only mention the common *Cysticercus cellulosæ* of the pig, which becomes the *Tænia solium* of man, the *Cysticercus* of the calf and ox, which becomes the *Tænia mediocanellata* of man, and the *Cysticercus longicollis* of the meadow vole, which becomes the *Tænia crassiceps* of the fox. Full details of the structure and development of the two former will be found in the second part of this work; but the genetic relations subsisting between most other known tapeworms and their larvæ have not yet been satisfactorily demonstrated, although there cannot remain a shadow of doubt that the developmental process is essentially the same throughout all the numerous members of this singular class of parasites.

Bothriocephalidæ.—In this great family I include all those cestodes which have their heads furnished with two or four opposed bothria or fossettes, whether these latter exist merely in the form of shallow pits or grooves, or whether they are developed into leaf-like appendages more or less prominent. A considerable number of the species are armed with hooks, which are usually placed at the upper part of the fossæ. All of them present elongated, depressed, and jointed bodies, but in a few forms the segments are not very clearly defined. The head varies much in the different genera, being usually conspicuous and much broader than the upper part of the neck. In some cases it is flattened and oval in outline, frequently truncate at the top, occasionally quadrangular, and very commonly spread out in the form of a tetrapetalous flower. The mature proglottides vary much in size, and also in respect of the position and form of their reproductive organs. In the more typical forms the segments are broad and narrow, having their reproductive outlets, side by side, at or near the centre of each joint; but other types display square-shaped and oblong segments, having their reproductive outlets at the lateral margins.

Structure and *Development.*—As a lengthened account will hereafter be given respecting the anatomy and reproduction of the great Bothriocephalus infesting man, I shall here confine my remarks to an account of the changes observable in the life of one or two forms infesting the lower animals. And first in regard to the *Bothriocephalus nodosus.* This species infests herons, gulls, divers, and a great variety of water birds, whilst its larval, or,

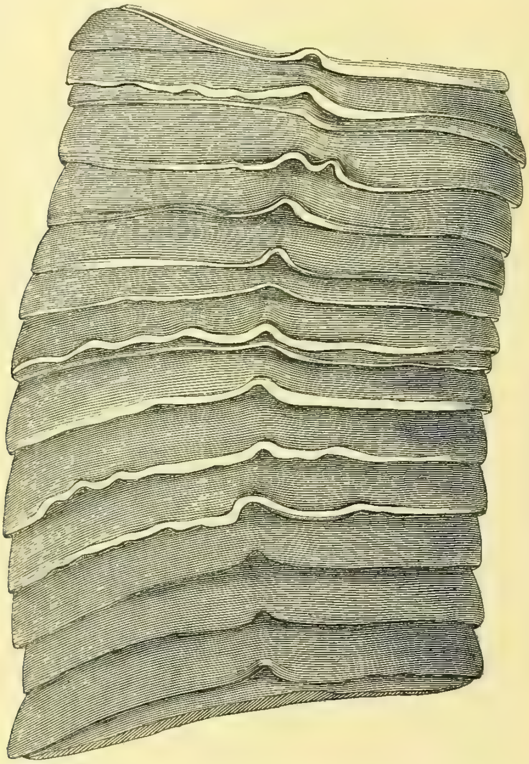

Fig. 29.—Part of the strobile of *Bothriocephalus proboscideus*, Rudolphi; from the intestine of a Salmon (*Salmo salar*); highly magnified.—Busk.

rather, its immature tænioid condition is a frequent inhabitant of fresh-water sticklebacks (*Gasterosteus aculeatus*, and *G. pungitus*), being also found in the salmon and in the common salt-water bull-head, or father-lasher (*Cottus scorpio*). The small sexually immature tapeworm was formerly considered a separate species, and was known under the title of *Bothriocephalus solidus*. Some years back Creplin discovered the connection subsisting between the two forms, and re-described the species in its two conditions under the name of *Schistocephalus dimorphus;* but it was reserved for Von Siebold to explain the full nature of this relationship. In his well-known essay on the "Tape and Cystic Worms," he shows that it is not until the worm reaches the intestine of the ultimate host that its segments acquire sexual completeness; and this is a law—as I have before had occasion to remark—which pervades all classes of parasites. As Von Siebold observes, "the extent of development in each individual will be found to be in proportion to the time the parasite has passed in the bird's alimentary canal after its passive immigration."* A similar instance, it is added, "occurs in the case of the *Ligula simplicissima*, infesting the abdominal cavity of various species of carp, whose sexual organs are, and remain, undeveloped, as long as the worm resides within the fish; whilst, when the latter is eaten by ducks, divers, waders, and other water-fowl, the entozoon being thus conveyed into their intestines, it attains perfect sexual development. In the older helminthological works the sexually mature *Ligula simplicissima* is described under various specific names, sometimes as *Ligula sparsa*, or *L. uniserialis*, at other times as *L. alternans*, or *L. interrupta*." There can be little doubt that many other so-called species of tapeworm infesting fishes will eventually turn out to be the juvenile forms of adult cestodes equally well known to science.

Genera.—*Bothriocephalus*, Rudolphi; = *Dibothrium*, Diesing; = (in part) *Tænia*, Linneus; = *Rhytelminthus*, Zeder; = *Rhytis*, Zeder; = *Schistocephalus*, Creplin; *Tetrabothrium*, Rudolphi; =

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* Band und Blasenwürmer, s. 41. See also Huxley's translation, p. 32.

Petalocephalus, Van Lidth de Jeude ; = *Onchobothrium*, Rudolphi ; = *Zygobothrium*, Diesing ; *Calliobothrium*, Van Beneden ; *Anthobothrium*, Van Beneden ; *Phyllobothrium*, Van Beneden ; *Echeneibothrium*, Van Beneden ; *Octobothrium*, Diesing ; *Diphyllobothrium*, Cobbold ; *Solenophorus*, Creplin ; = *Bothrydium*, De Blainville; = *Prodicœlia*, Leblond ; *Tricuspidaria*, Rudolphi ; = *Triænophorus*, Rudolphi ; *Hygroma*, Schrank ; = *Vesicaria*, Schrank ; *Echinobothrium*, Van Beneden ; *Bothrimonus*, Duvernoy ; *Ligula*, Bloch.

Particular types.—*Diphyllobothrium.*—I have applied this lengthened generic title to a remarkable species of parasite (*D. stemmacephalum*) which I discovered in the intestinal canal of a porpoise (*Delphinus phocæna*), shot by my friend Mr. J. Jardine Murray, in the Firth of Forth. For a considerable distance the gut was completely choked by the presence of five of these cestodes lying side by side. Four of the worms measured, respectively, from seven to ten feet in length, the fifth being about eighteen inches. This species, whose cephalic extremity

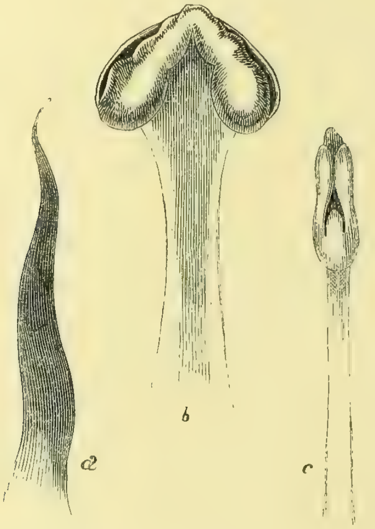

FIG. 30.—Three views of the head and neck of *Diphyllobothrium stemmacephalum*, Cobbold ; from the intestine of a porpoise (*Delphinus phocæna*) ; *a*, natural size ; *b* and *c*, × 100 diam.—Original.

is here figured, may be briefly described as follows:—Head triangular, flat, supported by a narrow neck, which increases rapidly in breadth, and is marked by numerous extremely fine transverse striæ; bothria, two in number, compressed laterally, narrow, supported on two sessile petaloid appendages, the latter, uniting at the summit of the head, to form, in profile, a semicircular festooned border; mature segments $\frac{1}{12}$ to $\frac{1}{6}$ of an inch deep, by $\frac{1}{2}$ an inch in breadth, displaying ten or twelve longitudinal furrows, whilst their inferior borders overlap each succeeding joint; reproductive orifices conspicuous, in the mesial line; length of the strobila upwards of one hundred inches.

Tricuspidaria.—Of this genus there is but one species known—under the synonym *Triænophorus nodulosus*—but it is widely distributed amongst our fresh-water fishes. It varies in length from one to two feet, but is seldom more than $\frac{1}{6}$ of an inch in breadth. The segmentation of the strobila is very indistinct, but the reproductive organs occur at regular intervals. All parts of the body are extremely contractile, and this is particularly the case with the head, which at different times presents very various forms. I notice the worm in this place chiefly with the view of again calling attention to certain peculiarities which I observed in a juvenile specimen obtained from the stomach of a pike. The points in question have reference to the cephalic hooks and calcareous corpuscles. It has not been generally noticed that the tricuspid hooks support thin chitinous laminæ, which connect the two lateral horns of each hook to the central apophysis. The object of this arrangement is probably to afford additional security to the prong-like processes, thereby rendering them capable of greater resistance; but whatever signification or use they may possess, their aspect curiously resembles the aortic valves of the human heart. As I have elsewhere remarked,* Van Beneden appears to think it an error that the cusps of the hooks should have been figured in the "Règne Animal," as directed forwards, and has himself, consequently, drawn the hooks with the points downwards.* On referring to the edition of Cuvier's work, edited by his pupils, I find Blanchard's figure to indicate an arrangement of the hooks precisely such as I have myself seen and figured, with the aid of a camera, more than once ;† in these cases the cusps were directed forwards. It can scarcely be doubted, therefore, that under different circumstances, the same animal may display the hooks in either direction, most probably by inverting and everting the head ; the performance of this function having hitherto, perhaps, escaped observation. In regard to the calcareous corpuscles situated in the neck of this worm, I may state that narrow vessels may be easily recognized, passing off continuously from the membranous capsules infesting the particles. These vascular prolongations, however, instead of forming inosculations,—as they are represented to do by Claparède in Holostomata,—are here single, having their very limited course directed outwards towards the clear structureless epidermis. It is highly probable that they open at the surface, but I have never been able to detect the slightest indication of any aperture. Dr. Guido Wagener figures a structure very analogous to this in his Haarlem Prize Essay,‡ where the appearance occurs in the tail of a larval trematode, namely, the *Cercaria macrocerca* of Filippi. No explanation of the structure is offered in the essay itself, and it becomes a very difficult task to interpret the phenomenon, the more especially so because the tubes do not appear to have any connection with the water-vascular system.

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* "Microscopical Journal," for 1859, p. 202.

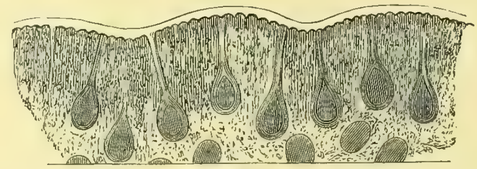

FIG. 31.—Portion of a very young *Tricuspidaria nodulosa*, Rudolphi; from the intestine of a pike (*Esox lucius*). Drawn with the aid of a camera ; × 300 diam.—Original.

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* "Les Vers Cestoïdes," Plate xxii.

† "Les Vers Intestinaux," Plate xxxix.

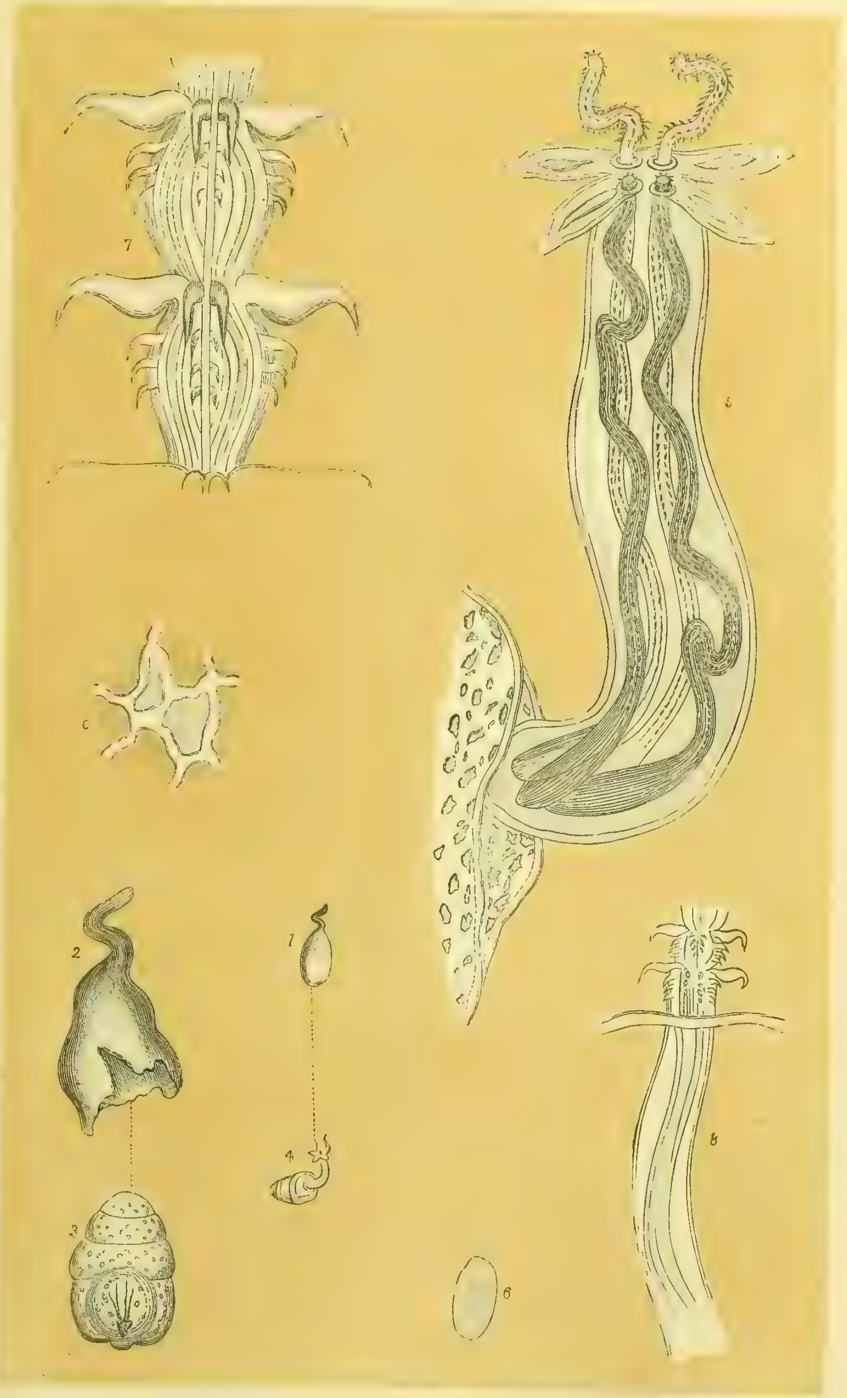
‡ "Entwicklungs-geschichte der Eingeweidewürmer," Plate xxix.

Tetrarhynchidæ. — The members of this family are easily recognized by the possession of four armed retractile proboscides attached to the head. The armature consists of several successive rows of sharply pointed recurved hooks, frequently amounting to several thousands. The head itself is usually more or less bilobed, each half supporting either one bipartite bothrium, or else two separate fossæ. These cavities are also frequently supported on four petaloid appendages, which vary much in shape in the different species, and also, in the same individual, according to the degree of contraction of the part. The head and neck are continuous, and usually about the same breadth as the body, the latter being sometimes even narrower than either the head or neck. The body is depressed, filiform, distinctly segmented, and usually of great length in the mature state; the reproductive orifices being situated at the lateral margin of the joints in an irregularly alternate manner.

Structure, Habits, and *Development.*—The various species of this family dwell only in the bodies of marine vertebrata, the mature forms being exclusively confined to the intestinal canal of sharks and rays, whilst the larvæ inhabit various fishes on which the plagiostomi feed. The immature forms also occur in cuttle-fishes, but they are most abundant in such fishes as the cod, haddock, turbot, flounder, sole, gurnard, mackerel, mullet, and conger-eel. One well-marked larva is an almost invariable guest in the muscles and viscera of the great sun-fish. If a number of these larval tetrarhynchs be taken indiscriminately from the above-named hosts, and be compared with one another, it is surprising how greatly the forms will be found to differ. This difference has reference not so much as respects their size and general appearance, but rather as regards the form of their proboscides and the relative number and disposition of the hooks which they carry. Into details respecting these variations it is needless to enter, especially as the selection of any one form will suffice to convey an accurate conception of the leading structural peculiarities belonging to the group.

The accompanying drawings (Plate IX.) represent a scolex or larval tetrarhynch, which I removed from the wall of the intestine of a common haddock. It was associated with several other larvæ of the same kind, the individuals varying in size from a pin's head to that of a pea. Each young Tetrarhynchus was enclosed in a thick-walled sac (fig. 1), which, when burst open, set the larva free. The sac itself is made up of two distinct layers, an inner smooth one (endocyst), and an outer fibrous layer (exocyst) consisting of dense bands of connective tissue. Immediately on its escape the larva is seen to consist of an oval mass, at the surface of which a few transverse folds are plainly discernible, and also a number of minute dots which are visible with a low magnifying power (fig. 3). Within the vesicle a second round and much smaller vesicle is distinguishable, and within this latter, again, distinct traces of the head are rendered apparent by the aid of transmitted light. On pressing the larva between two glasses the inner vesicle readily protrudes at one end of the mass, and, by carrying the pressure still further, the head and neck themselves may be everted (fig. 4). The large outer bladder-like vesicle, is, in fact, the tail of the scolex; the second vesicle being only its anterior pole inverted, and enclosing the introverted head and neck. Whilst still within the caudal vesicle, the four long filamentary proboscides were readily discernible, whilst the dots, just alluded to, are the well-known calcareous corpuscles. When highly magnified these several parts became much more significant. The head, of uniform breadth with the neck, supported four quadrangularly disposed leaf-like appendages, each of these organs being pointed at the free end and slightly hollowed out at the upper surface to form the characteristic bothrium (fig. 5). At the base of each appendage (auricle) is a minute papilla-shaped opening, through which a proboscis is darted out somewhat after the fashion of a projectile. The four openings lead into four long, cylindrical, muscular channels, in which the proboscides were lodged in their retracted condition. These sheaths extended all the way down the neck to

PLATE IX.



Scolex of Tetrarhynchus.

T. S. C., delt.

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within a short distance of the commencement of the caudal vesicle, at which point they severally terminate in club-shaped enlargements. Each proboscis itself appeared to be tubular, being connected to the club-shaped pouch by a special muscle (*retractor proboscidis;* fig. 8). The walls of the pouch are very thick, and from their muscular character seem to be the principal source of the protrusive power of the armed proboscides. In point of fact, the whole apparatus may be compared to a military weapon, in which we have a long barrel formed by the muscular sheath, an orifice comparable to the muzzle, an armed rod forming the projectile, a special muscle forming a connecting cord, and a strong breech as a *point d'appui* for the development of the propelling force. In some tetrarhynchs these pouches present a more oval or rounded figure, and there is every possible variety in the length and caliber of the sheath and its contained proboscis. The same variations are noticeable as regards the armature of hooks for boring. In the present case each proboscis is supplied with two or three hundred circular rows of hooks, four to each row, but the size and configuration of the hooks are by no means uniform. There are, in fact, four different sizes, which are repeated at regular intervals, each group of sixteen occupying, as it were, a distinct section or segment of the proboscis. Of these four circles, the uppermost of the series is disproportionately developed. Altogether there must be several thousand hooks. These organs are employed as instruments for boring through the flesh and tissues of the host; and from their peculiar construction they may be looked upon as four chain saws, whose efficiency is very greatly increased by the circumstance that each chain presents four serrated edges, the teeth of which are of four different sizes. Not a few Tetrarhynchi exhibit even a still more complex armature, as may be seen in the *Tetrarhynchus longicollis* infesting the tope or penny-dogfish (*Galeus vulgaris*).* It may be difficult in some instances to understand how any real advantage could accrue from a more complex disposition of the hooks, but the mere fact of their frequent variations in size —with constancy in the several species—shows that such arrangements are by no means accidental. In the species just named, however, the hooks are uniform in size, and arranged in spirally disposed circles, carrying from twenty to thirty hooks each. In another form, we find a marked irregularity both as regards the size and disposition of the hooks. This is shown in the accompanying cut taken from a drawing executed by Mr. Busk. In this figure it will be noticed that the bases of the hooks are suddenly enlarged and implanted in the substance of the contractile tissue of the proboscis. It is seldom that these root-like processes are so conspicuously developed. The larva from which this fragment is taken was not much larger than an ordinary pin's head, being enveloped by a cyst precisely like the one above described. Nearly all the larval Tetrarhynchi exhibit the cystic character so universal in the scolex condition of ordinary tapeworms; occasionally, however, this cyst-like character is almost totally lost, the entozoon remaining sexually immature and groping about with restless

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* Other forms are figured and described in Van Beneden's earlier quarto work, "Les Vers Cestoïdes," p. 151, *et seq.*, Plates xv.—xx.

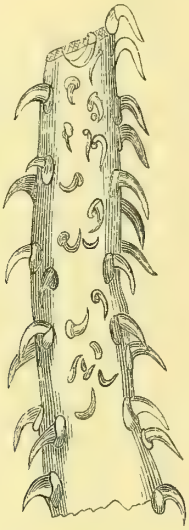

FIG. 32.—Portion of the proboscis of a *Tetrarhynchus* in the scolex condition; from the abdomen of a whiting (*Merlangus vulgaris*); highly magnified.—Busk.

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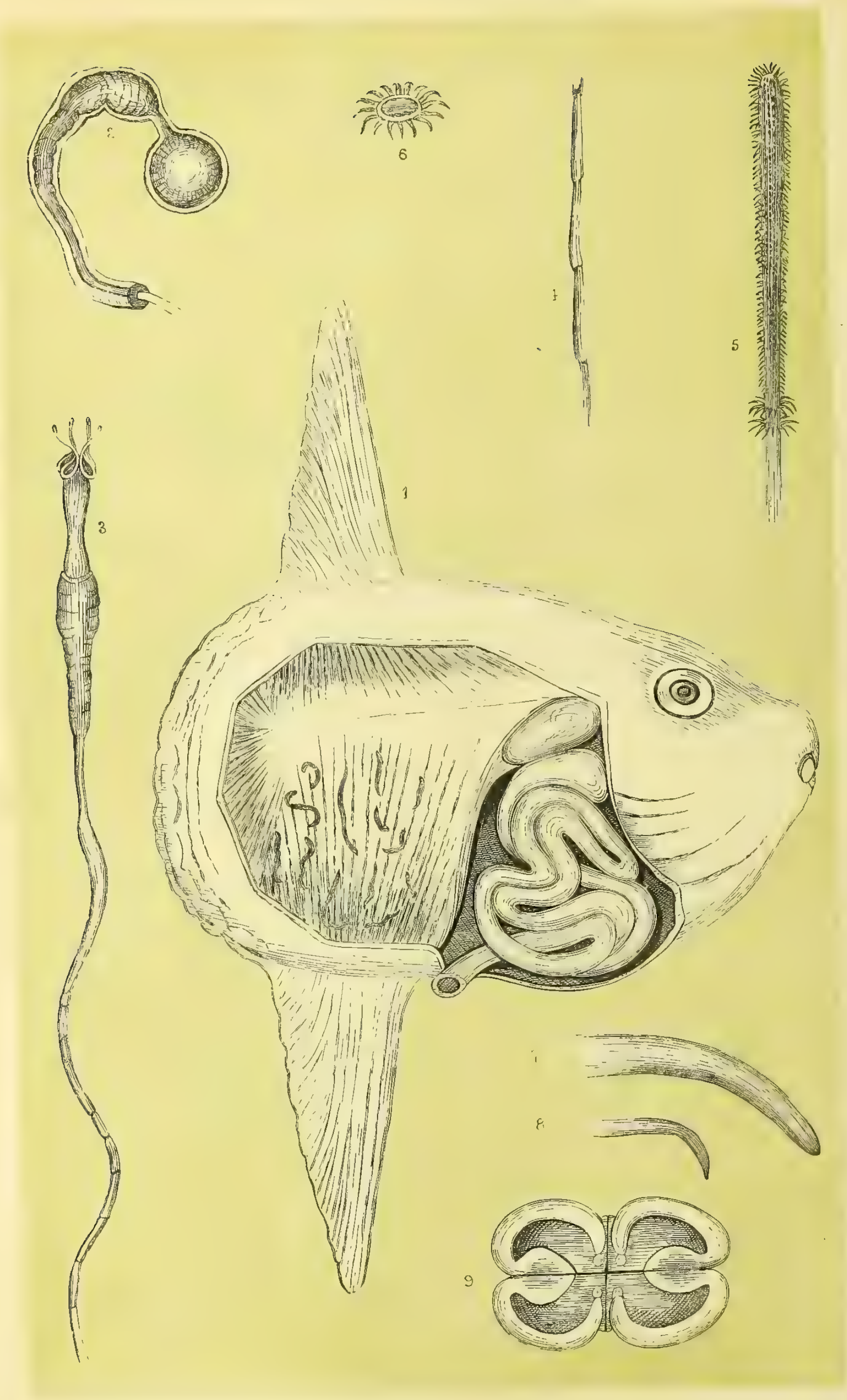

Tetrarhynchus reptans,[1] Cobbold.

T. S. C., delt.

activity to gain access to its ultimate host. This is particularly the case with a remarkable form of parasite infesting the sun-fish (*Orthagoriscus mola*)—a worm which has been described over and over again by observers, each author imparting to the species either a new specific or generic name. It is, generically, a true tetrarhynch, but has seldom, if ever, been regarded as such by previous entozoological writers.*

Of the five or six examples of the sunfish which I have either had an opportunity of inspecting or dissecting in the fresh state, all of them, if I recollect rightly, were infested by the tetrarhynch in question. The fish here figured was a particularly small one; nevertheless, the liver and great lateral muscles were extensively tunneled by the parasite in question (Plate X., Fig. 1).† In all cases the anterior part of the worm is invested by a thick, clear, transparent cyst which closely invests the animal, but gradually diminishes in thickness towards the tail. At this part it can be traced in the tissues of the host for a considerable distance beyond the caudal extremity of the entozoon, forming a thin cord which serves to indicate the track previously taken by the wandering scolex. It is doubtful if any one has ever succeeded in tracing the cord to the point of the parasite's original departure, *i.e.*, from the spot where the animal became transformed from the condition of an embryo into the characteristic scolex state. The earliest conditions of the scolex, of the embryo (*proscolex*), and of the mature proglottis, are, I believe, at present unknown to science, but it is more than likely that the sexually mature worm is one or other of the various species of tetrarhynch already described by systematists as infesting the larger sharks. Be that as it may, we have here a remarkable illustration of the power of the scolex to form the tænioid condition until it has reached a length of two or more feet; at the same time, it is wandering about the viscera and muscles of its intermediate piscine host, growing rapidly and developing well-marked joints, without acquiring, apparently, the slightest indication of sexual organs. When these parasites are numerous, —as is commonly the case, and I have seen scores of such scolices in the liver of a single fish,—it becomes extremely difficult to unravel their tortuous windings; for not only is their course often very erratic, especially in the liver, but they twist round one another so as to form a complicated network of cords. In the case of the young fish, here figured, the parasites were comparatively few in number, those from the muscles being more readily dissected out. On being removed several were dropt into a tumbler of sea-water, when, to my astonishment, they moved about actively; I say "astonishment," because the fish had been dead nearly an entire week, and had been cast aside, as refuse, by the fish-salesman of whom it was purchased. On being deprived of their investing capsules, the proboscides were protruded and retracted in an irregular alternating manner. These movements continued for three days. The longest specimens of the parasite measured about twenty inches, but I had previously met with examples which were probably double that length.

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* Synonyma:—*Gymnorhynchus reptans*, Rudolphi; = *G. horridus*, John Goodsir; = *Acanthorhynchus reptans*, Diesing; = *Bothriorhynchus continuus*, Van Lidth de Jeude; = *Bothriocephalus patulus*, Leuckart; = *Anthocephalus elongatus*, Rudolphi; = *A. macrourus*, Bremser; = *Floriceps saccatus*, Cuvier; = *F. elongatus*, Blainville; = *Scolex gigas*, Cuvier; = *Tetrarhynchus reptans*, Cobbold.

† It was captured off Anstruther on the coast of Fife, September 6th, 1856. The dimensions were as follows:—Length from head to tail, 18 inches; between tips of dorsal and anal fins, 26 inches; depth of body, 12 inches; length of pectorals, 2½ inches; width of gill aperture, 1 inch. Several other individuals were taken in the Firth of Forth a few weeks previously. The larger specimens were infested with other forms of entozoa, in addition to the ectoparasitic trematode helminth known as the *Tristoma coccineum* of Rudolphi.

Whilst still within their capsular coverings, these tetrarhynchs display a globular projection at their anterior extremity (Fig. 2). This appearance at first conveys the notion of a head, followed by a narrow neck; in reality, however, the little ball includes not only the head and neck, but a remarkable sub-cervical enlargement which is interposed between the so-called neck and the upper division of the body. These parts are readily seen when the animal is liberated (Fig. 3). The head itself, when viewed from above, displays a quadrilateral figure, with the angles rounded off, each lateral half being furnished with a bipartite facet, which, in form, presents a remarkable resemblance to the under surface of a cloven foot with the digits pointing outwards. The four bothria thus appear to merge into one another towards the centre of the head, near which point the openings of the four proboscis-sacs are brought into view. The retractile boring-organs are club-shaped, each being furnished with an armature of hooks, differing in many respects from those I have previously described. It was difficult to ascertain their number precisely, but after careful and oft-repeated examinations, I arrived at the conclusion that each circular row consisted of sixteen hooks (Fig. 6), whilst there appeared to be fully one hundred of these rows on each proboscis. Each proboscis was therefore calculated to support 1600 hooks; which therefore gave, altogether, a total of upwards of 6000 of these little instruments on a single head. Nearly all the hooks displayed a uniform length and thickness, but at the lower part of each proboscis there were two conspicuous circles, the hooks of which were at least twice as large as the others (Figs. 7 and 8). The smaller hooks are curved, retroverted, and sharply pointed at their tips; the larger ones being less arcuate, less retroverted, and comparatively blunt at their extremities. Finally, in regard to the neck and body, it only remains for me to add that the former is, in the first instance, continuous with the head, subsequently becoming enlarged, and then afterwards contracting, as suddenly, before it re-enlarges to form the upper part of the body. At this point traces of segmentation commence, becoming more and more evident as we pass downwards, until the joints are well formed; and these latter, but for the absence of sexual organs, would probably not be distinguishable from the proglottides of the adult strobila.

Several questions here naturally suggest themselves, such as,—What is the object of this perpetual tunnelling? Does the boring cause suffering to the host? Do the parasites ever make their escape from the body of the fish, by their own unassisted powers?

To the first question I reply that the object of tunnelling is apparently two-fold: first, that the animal may constantly obtain fresh nourishment; and secondly, because the creature is impelled by instinct to seek out another residence. It may be objected that neither of these reasons are satisfactory, for the parasite is not supplied with digestive organs, neither can it gain access, by itself, to another dwelling. It should, however, be observed that as it acquires nutriment by imbibition through the general surface of the body, a change of locality would facilitate growth, and render such imbibition more easy; whilst, on the other hand, a long stagnation at any one spot would sooner or later bring on cretification and death. It is, certainly, a curious example of an animal perpetually striving to perform an act which it cannot accomplish; for, in order to arrive at sexual maturity, it must wait until the sunfish is devoured by a shark. In regard to the question as to the boring-action giving rise to pain, one cannot, of course, speak with certainty; but from the slowness of the process and the extreme minuteness of the boring-apparatus, I think it very doubtful if the presence of the parasites is even felt at all. When, however, there are many of them, and when, by their complex and continued movements they have injured the secreting parenchyma of the liver, or any other important viscus, then, doubtless, they give pain, indirectly, by causing the decay of the organ infested and a consequent enfeebling of the vital powers of the animal. It is at such a time that the sun-fish would be easily overcome by its natural enemies, and the piscine life would be sacrificed in favour of the long-imprisoned guests. So far as our observation extends, these wandering scolices never escape by themselves from the body of the intermediate host, but are in all cases passively transferred into the alimentary canal of the ultimate entertainer. In the Sharks and Rays the parasites probably acquire sexual maturity very rapidly, and whilst within these animals the proglottides and their contained embryos, doubtless, pass into the water in the ordinary way; the ova are subsequently swallowed by various fishes, and the embryos are liberated within the stomachs of these new hosts after the manner commonly occurring in the tapeworms, properly so called. How far the embryos (proscolices) differ from those of the Tæniadæ, and what changes they undergo during their conversion into the scolex state, are points which do not yet appear to be entirely made out. In their general structure the hermaphroditic proglottides closely resemble the joints (or deuterozooids) of ordinary tapeworms.

Genera.—*Tetrarhynchus*, Rudolphi; = (in part) *Bothriocephalus*, Leuckart; = *Dibothriorhynchus*, Diesing and Blainville; = *Heptoxylon*, Bosc; = *Gymnorhynchus*, Rudolphi; = (in part) *Anthocephalus*, Bremser and Rudolphi; = *Floriceps*, Cuvier; = *Acanthorhynchus*, Diesing; = *Bothriorhynchus*, Van Lidth de Jeude; = *Scolex*, Cuvier; *Pterobothrium*, Diesing; *Rhynchobothrium*, Rudolphi; *Tetrarhynchobothrium*, Diesing; = *Tetrabothriorhynchus*, Diesing; *Synbothrium*, Diesing: = *Corynesoma*, Leuckart; *Stenobothrium*, Diesing; = *Tentacularia*, Bosc.

PART II.

SPECIAL HELMINTHOLOGY;

OR AN OUTLINE OF THE ANATOMICAL PECULIARITIES, ORIGIN, MODE OF DEVELOPMENT AND PROPAGATION OF THE ENTOZOA INFESTING MAN; WITH A PARTICULAR ACCOUNT OF THE INJURIOUS EFFECTS THEY PRODUCE, INCLUDING A BRIEF NOTICE OF THE REMEDIES EMPLOYED IN MEDICAL PRACTICE.

HUMAN ENTOZOA.

CHAPTER I.

TREMATODA.

Importance of experimental research in human helminthology—Species of entozoa infesting man—The common liver fluke, or *Fasciola hepatica*—General and specific characters—History and nomenclature—Distribution and descriptive anatomy—Comparison with *Fasciola gigantea*—Special structural peculiarities.

At the Cambridge Meeting of the British Association for the Advancement of Science, in 1862, I adduced the following argument in favour of a more extended prosecution of experimental research in the department of human helminthology:—"As man is infested by a great variety of internal parasites, and some of them prove exceedingly troublesome, it is evident that a large amount of practical good would ensue if we were more perfectly informed respecting the origin and economy of these creatures; for not only are our personal interests directly affected by their intrusion, but we also suffer indirectly from the injury and destruction they occasion amongst our domesticated animals. At least thirty well-marked forms have been described as infesting the human body; and although most of the species are comparatively rare, yet a considerable number are exceedingly common in occurrence, and likewise often prove numerically abundant in one and the same individual."

This argument was supported by a reference to certain facts then recently ascertained, a more particular account of which, combined with the results of my own inquiries, was subsequently submitted to the consideration of the members of the Zoological Society of London, and afterwards published in their Proceedings. In the present work I propose to enter upon the consideration of all the human parasites somewhat after the same method as the one then adopted, dwelling, however, in this case, not only at a much greater length on the structure and economy of nearly all the parasites there mentioned, but also describing with considerable detail those particular species which more or less frequently produce fatal results.

In the subjoined list of the human entozoa, I only record those which are perfectly distinct forms, and therefore, for the most part, good species. Many parasites which were at first supposed to be distinct will be found in the synonyma placed at the head of each article where the species is separately considered. The larvæ are noticed under the titles of the adults to which they are either known or presumed to be respectively referable. This method is followed even in cases where the adult condition is not known to occur in the human body or in any other "host:" thus, for example, the *Cysticercus acanthotrias* is placed under *Tænia acanthotrias,* although the mature tapeworm at present remains unknown. The various specie will be found described in the following order:—

HUMAN ENTOZOA.

1. *Fasciola hepatica,* Linneus.
2. *Distoma lanceolatum,* Mehlis.
3. *Distoma ophthalmobium,* Diesing.
4. *Distoma crassum,* Busk.
5. *Distoma heterophyes,* Siebold.
6. *Bilharzia hæmatobia,* Cobbold.
7. *Testrastoma renale,* Delle Chiaje.
8. *Hexathyridium pinguicola,* Treutler.
9. *Hexathyridium venarum,* Treutler.

10. *Tænia solium*, Linneus.
11. *Tænia mediocanellata*, Küchenmeister.
12. *Tænia acanthotrias*, Weinland.
13. *Tænia flavopuncta*, Weinland.
14. *Tænia nana*, Von Siebold
15. *Tænia elliptica*, Batsch.
16. *Tænia marginata*, Batsch.
17. *Tænia echinococcus*, Von Siebold.
18. *Bothriocephalus latus*, Bremser.
19. *Bothriocephalus cordatus*, Leuckart.
20. *Ascaris lumbricoides*, Linneus.
21. *Ascaris mystax*, Rudolphi.
22. *Trichocephalus dispar*, Rudolphi.
23. *Filaria lentis*, Diesing.
24. *Filaria trachealis*, Cobbold.
25. *Trichina spiralis*, Owen.
26. *Strongylus bronchialis*, Cobbold.
27. *Eustrongylus gigas*, Diesing.
28. *Sclerostoma duodenale*, Cobbold.
29. *Oxyuris vermicularis*, Bremser.
30. *Dracunculus medinensis*, Cobbold.
31. *Dracunculus Loa*, Cobbold.

In the above list it will be observed that I have purposely omitted the acarine genus *Pentastoma*, the annelid (*Dactylius aculeatus*) described by Curling, Farre's *Diplosoma crenatum*, the *Spiroptera hominis* of Rudolphi, and many other *pseudelminthic* internal parasites, which will be either described or noticed in the third part of this work.

1. FASCIOLA HEPATICA.

F. hepatica, Linneus; Pallas; Fabricius; etc.
F. humana, Gmelin.
Distoma hepaticum, Abildgaard; Zeder; Mehlis; etc.
Planaria latiuscula, Goeze.

General and Specific Characters.—A trematode helminth, usually about three-fourths of an inch in length, but occasionally measuring an entire inch or even fourteen lines, its greatest breadth also varying from half an inch to seven or eight lines transversely; body very flat, presenting distinct dorsal and ventral surfaces, frequently curved toward the latter during life; upper or anterior end suddenly constricted, produced, rounded, and pointed, forming the so-called head and neck; posterior extremity less acuminated, sometimes rounded, or even slightly truncated; margins smooth, occasionally a little undulated, especially towards the upper part; oral sucker terminal, oval, rather smaller than the ventral (acetabulum), which is placed immediately below the root of the neck; reproductive orifices in the middle line, a little above the lower sucker; intromittent organ usually protruded and spirally curved; a central, light-coloured space, extending two-thirds of the body from above downwards, marks the region of the internal male reproductive organs, being bordered on either side and below by a continuous dark band, indicating the position of the so-called yelk-forming organs; a small, brown-coloured, rosette-like figure, placed directly below the ventral acetabulum, shews the limits of the uterine duct; a series of dark lines, branching downwards and outwards on either side, marks the position of the digestive organs; general colour of the body pale brownish-yellow, with a slight rose tint.

History.—This entozoon, familiarly called the liver-fluke, has been known from the earliest times, and may almost be said to have acquired a literature of its own. We have clear evidences that it was described by Gabucinus in the year 1547, and also subsequently by Cornelius Gemma, who, in a work published some thirty years later, refers to an epizootic disease prevalent in Holland during the year 1552, and which was very justly attributed to the parasite in question. After this date many writers described the liver-fluke more or less accurately, and entire volumes were devoted to the consideration of the formidable disease which it occasions. In the recent work by M. Davaine, we are furnished with a brief *résumé* of the principal facts bearing upon the history of the Fasciola, together with numerous references to ancient authorities; therefore, it is unnecessary here to do more than refer those who desire further information on this subject to his excellent treatise.*

Name.—The scientific nomenclature of this parasite involves a question of some importance. Amongst naturalists, generally, the common liver-fluke is continually described under the combined generic and specific titles of *Distoma hepaticum;* but working parasitologists, who are at the same time acquainted with the writings of the earlier scientific observers, know very well that these titles are both incorrect and inappropriate. The proper generic appellation of this parasite is *Fasciola,* as first proposed by the illustrious Linneus (1767), and subsequently adopted by F. Müller (1787), Brera (1811), Ramdohr (1814), and others. Unfortunately, however, Retzius (1786) and Zeder (1800) changed the generic title without good cause, and the majority of writers, following their authority, obstinately refused to employ the original name, although fair dealing with the posthumous reputation of its distinguished author, and a consideration of the distinctive types of structure displayed by the two genera (*Distoma* and *Fasciola*), alike demand the retention of the Linnean title. In later times, M. Emile Blanchard (1847) of Paris, has strongly advocated the final adoption of the original nomenclature, and the writer himself has also from time to time (in 1854-56-58-60, and 1862) demonstrated the propriety of rejecting the commonly-received synonyme. Another distinguished French naturalist, namely, Professor Moquin-Tandon, has also employed the term *Fasciola,* but by placing in the genus several species not properly belonging to it, such as *Distoma lanceolatum* and *Distoma heterophyes,* he has unwittingly rendered " confusion worse confounded."

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* "Traité des Entozoaires, et des Maladies Vermineuses," etc. p. 235, *et seq.* Par C. Davaine. Paris. 1860.

Distribution.—The *Fasciola hepatica* is not only of frequent occurrence in all varieties of grazing cattle, but has likewise been found in the horse and ass by Daubenton ; also in the hare and rabbit by the writer himself and others, in the squirrel by Tozzetti as previously mentioned, in the great kangaroo (*Macropus giganteus*) by Bremser and Diesing, in various antelopes and deer by Pluskal, etc., and also in the beaver (*Castor fiber*) by Czermack. Its occurrence in man has been recorded by Pallas, Bidloo, etc. ; doubtful instances being also given by Mehlis and Duval. More recently, Professor Partridge, of King's College, detected it in the human gall-bladder, particulars of the case being described in the second edition of Dr. Budd's well-known treatise on "Diseases of the Liver." Giesker of Zurich mentions an undoubted example where the Fasciola had lodged in the sole of a woman's foot, whilst a similar case came under the observation of Mr. Fox of Topsham, Devonshire, the entozoon being located beneath the skin, about three inches behind the ear. Mr. Harris of Liverpool has likewise related an example where six or seven flukes had apparently penetrated the scalp of a little child, and there is every reason to believe that all of them were referable to the species under consideration. These cases, and others, will be again alluded to subsequently.*

Descriptive Anatomy.—If an adult specimen of full size be selected for examination, the surface of the body will appear, to the naked eye, smooth throughout, but if a pocket lens be employed, the skin will be seen covered with numerous little processes or spines. These spines are broad at the base, and pointed at the apex; they measure $\frac{1}{357}$ of an inch in length, and $\frac{1}{833}$ of an inch in breadth. They resist the action of the ordinary acid and alkaline reagents, and are chemically composed of chitine. If the skin to which they are attached be gently raised by means of the forceps it will be found to consist of two layers, an outer, thin, transparent cuticle (epidermis), and an inner, dense, fibrous *cutis vera*. The spines are often very loosely connected to the surface of the former, and in old specimens they are sometimes almost entirely wanting; at all times, they are more strongly developed anteriorly than in the caudal region. This is the case with most of the other armed trematodes.

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* In the "Boston Medical and Surgical Journal," for the years 1852-53-54, Dr. J. X. Chabert has described several cases of Tænia, and it is averred that the tapeworms were associated with numerous specimens of *Distoma hepaticum*. The passage of distomes by patients during life is even regarded by Dr. Chabert as indicative of the presence of Tænia within the intestines. Surely Dr. Chabert must be mistaken. Are not these so-called distomes the well-known *proglottides?* Not wishing to doubt Dr. Chabert's statements, but, on the other hand, desirous of verifying the accuracy of the facts placed on record, I wrote (March 22nd, 1864) to Dr. Chabert (at his residence, 431½, Grand Street, New York, U.S.) to request the favour of the possession of one of the specimens. Up to the present time, however (June, 1864), I have not been fortunate enough to receive a reply. In the "Case of Tænia" in a boy four and a half years old, given in the 49th vol. of the Journal, Dr. Chabert writes as follows:—"In consequence of his passing the *Distoma hepaticum*, I concluded he must be afflicted with Tænia." Further on it is added, that the administration of an astringent injection "caused the discharge of innumerable small worms (*Distoma hepaticum*)." Can anything be more decisive than this? No helminthologist, past or present, ever recorded such a case.—T. S. C.

Beneath the skin are found numerous bands of muscular fibres, in which four separate groups may be recognized more or less distinctly. They have been described as so many layers, but they are not readily separable from one another. Well-marked longitudinal and transverse fibres may be seen at all parts of the body, and two series of diagonally directed fibres, some passing downwards from right to left, and others from left to right. The fibres themselves belong, of course, to the non-striated kind of muscle, and consist of narrow, fusiform cells, measuring from $\frac{1}{417}$ to $\frac{1}{277}$ of an inch in length, and having a breadth of about the $\frac{1}{8333}$ of an inch. They are flattened throughout, and display a single oval nucleus, which refracts light rather strongly. Towards the anterior end of the body all the groups of muscular fibres are more strongly developed.

The general parenchyma of the fluke consists of rather loosely-connected and irregular polygonal cells of unusually large size, measuring from $\frac{1}{357}$ to $\frac{1}{277}$ of an inch in their greatest diameter (Leuckart). The margins are well defined, and there is a distinct nucleus ($\frac{1}{3570}''$ to $\frac{1}{2500}''$) presenting a finely granular appearance. A clear, transparent, homogeneous fluid occupies the interior of the cells.

All the tissues of the body possess highly contractile properties, but the fluke is undoubtedly aided in locomotion both by the oral and ventral sucker. These organs may be regarded as specialized developments of the transverse and longitudinal system of fibres, which have become exaggerated to serve a distinct purpose. The oral sucker is perforated in the centre, and communicates with the œsophagus, but the ventral is imperforate, consisting simply of a cup-shaped disk, forming a sort of alveolus with a thick, circular, prominent margin. In both, two distinct sets of fibres are distinguishable, that is, a circular series and a radial group. These bundles interlace one another, forming powerful sphincters, which, when applied to any soft surface, must, during full action, produce a very considerable vacuum in the centre of the disk. The oral sucker differs only from the ventral in respect of size and incompleteness at the lower part, in which latter situation it is either connected with or prolonged into a series of fibres forming the so-called pharynx. As far as my own observations extend this special muscular development corresponds with the œsophageal bulb, which in other trematode species is often entirely removed from its connection with the oral sucker, and consists of two sets of fibres as obtains in the sucker itself. Mr. Simonds, however, only recognizes one set of fibres, and says that "these fibres run lengthways by the side of the (œsophageal) tube, reaching from its upper to its lower part, and so embracing it as to form an elongated sphincter." My own observations appear to be borne out by the independent and earlier inquiries of Mr. Busk, from whose drawings the accompanying figure is selected. The sucker here figured is taken from

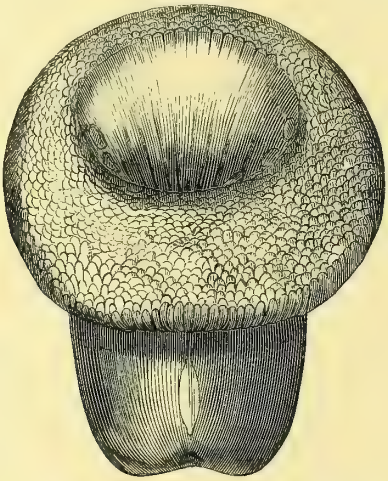

Fig. 33.—The oral sucker of a small species of fluke (× 220 diam.).—Busk.

a different species of trematode, but in all essential features it is the same as that of *Fasciola hepatica*. The radial fibres when viewed from above display a cellular appearance, the individual fibres being seen, as it were, in transverse section.

As before remarked, these suckers are both employed as organs of locomotion, but the lower one also undoubtedly serves as an anchor or holdfast. The oral disk will also materially assist as a prehensile organ for taking in the biliary secretion on which the animal feeds, whilst the pharyngeal sphincter will, as Simonds

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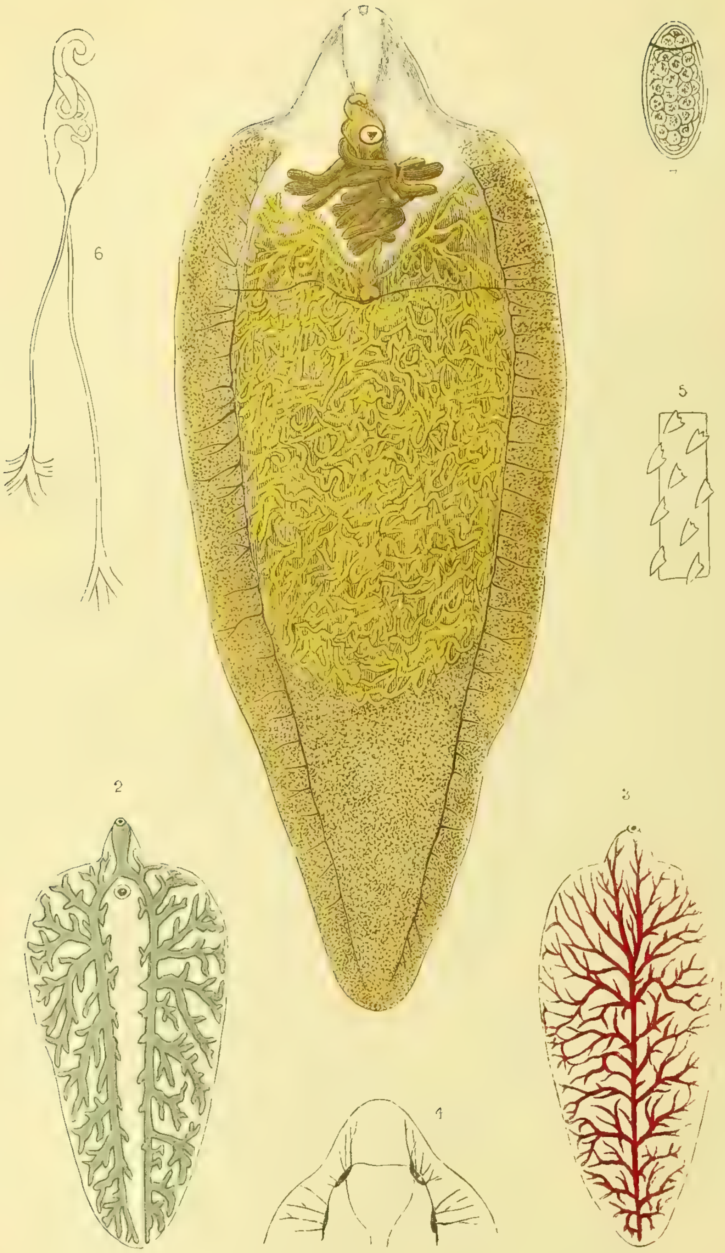

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After Blanchard.

believes, serve to prevent the regurgitation of the food after it has distended the stomachal passages. All who have had much to do with fresh living flukes must have observed a tendency to eject the stomachal contents, immediately on their removal from the liver of their host. The cold air—like the more cruel stimulus of salt applied to the skin of a recently gorged leech—causes the body of the fluke to contract and curl upon itself, and the animal probably derives some relief by allowing the food to escape by the oral outlet.

Mention of these phenomena naturally lead to the consideration of the digestive system. The mouth, as we have seen, is placed at the apical or lower part of the cup-shaped cavity of the anterior sucker. In this situation it leads into a comparatively short œsophagus (about $\frac{1}{125}''$ in diameter) which subdivides into two primary intestinal divisions, the point of bifurcation being situated immediately above the location of the external reproductive orifices. The two primary digestive tubes run downwards in a parallel manner on either side of the central line, until they reach the caudal extremity. During their passage downwards they give off a variable number of secondary tubes, which likewise in their turn give off others, which subdivide, more or less frequently, when at length all of the branches ultimately terminate in blind cœcal extremities (Plate XI., Fig. 2). A few short twigs are also given off from the primary straight tubes, being directed towards the middle line, where they terminate very abruptly, but frequently giving evidences of an effort, as it were, on their part to develop tertiary tubes. In the region of the head and neck, the secondary branches are directed upwards and outwards; lower down they diverge more directly outwards, whilst at the middle and lower part of the body they slant obliquely downwards toward the lateral borders. Altogether they form a beautiful series of dendritically ramifying canals, preserving on either side a tolerable, but not entirely uniform, degree of regularity; moreover, the two halves of the system do not completely correspond, or, in other words, the symmetry is not extended beyond the general disposition of the main branches. In no case have I witnessed any intestinal anastomoses. Several observers have represented the secondary and tertiary branches as becoming smaller and smaller as they proceed towards the margin, also conveying the idea that the ultimate branchlets are extremely fine. This is decidedly an error, and shows that their descriptions have not been taken from artificially injected specimens. The truth is, that the ultimate branches, as well as their cœcal ends, are only a very little smaller than the primary intestinal trunks. Histiologically speaking, the alimentary tubes consist of two layers; an outer fibrous wall made up of thin filaments, and an inner, cellular layer, consisting of columnar cellules, which, when viewed in front, present a polyhedral figure. According to Leuckart, they have a breadth of $\frac{1}{1460}$ of an inch. The fluid intestinal contents are, for the most part, made up of bile derived from the gall ducts of the host, in which there may also be frequently observed numerous epithelial scales as well as blood corpuscles derived from the same source. These matters are therefore, manifestly, the principal source of nutriment by which the fluke is supported; but it is also probable that other nutrient fluids, absorbed by the skin, contribute their quota towards the growth and nourishment of the animal.

In strong contrast to the digestive system of canals, there is another series of tubes lying in closer proximity to the dorsal surface of the body, and presenting features altogether distinctive. I here speak of the so-called aquiferous or water-vascular system. In favourable examples of the worm, every part of this set of vessels may be viewed by the aid of a pocket lens, even in cases where there has been no attempt made to inject them. In such examples I find one central, longitudinal trunk ($\frac{1}{50}''$ broad), extending backwards from the upper third of the body in a direct line to the extremity of the tail, at which point it terminates in an open *foramen caudale* (Plate XI., Fig. 3). At the spot coinciding with an imaginary line marking the upper third of the body, the single main trunk divides into three branches, two of which approach the ventral surface, slightly diverge and pass forward towards the head, whilst the third is continued on the dorsal surface in the middle line, forming, as it were, a continuation of the main trunk. This branch, however, is the most feebly developed of the three. During its course upwards towards the head, the main trunk gives off a variable number of main primary branches, all of which are directed diagonally upwards and forwards ; and besides these, there are many smaller primary branches intercalated, as it were, between the larger primary vessels. At a short distance from the central line, these vascular branches freely anastomose by the intervention of secondary and tertiary branches, and also by intermediary twigs, which cannot be said to be referable to one main branch more than another. Some of the non-anastomosing ultimate twigs, which are very numerous, are directed towards the dorsal surface, where they terminate in cœcal extremities immediately below the muscular layers, whilst others are continued towards the lateral margins, where they also terminate in a similar manner. Under the half-

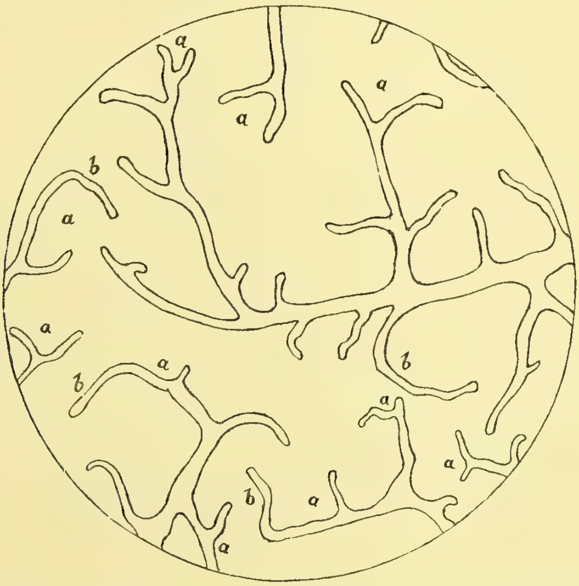

Fig. 34.—Mode of termination of the cœca of the so-called excretory or water-vascular system of canals in *Fasciola hepatica* (× 40 diam.). Outlined with the aid of a camera.—Original.

inch objective the precise mode of their final distribution is readily seen. The ultimate twigs lose that rigid, straight, tubular character which the primary trunks display, and twist somewhat irregularly, like the mycelium of a fungus. The final division is almost invariably bifurcate, in which case, however, there is frequently much disparity as regards the relative length of the divisions. In the foregoing woodcut, these appearances are correctly given (*a*, *a*, Fig. 34). The cœcal extremities are always separated from one another by an interspace more or less considerable, and the final twigs often appear to have gone out of their way, as it were, in order to avoid the contingency of union. They seem to say "union is impossible," and bend suddenly upon themselves, at an acute angle, to get out of the way of opposing vessels coming from other directions (*b*, *b*, Fig. 34).

Having succeeded with my injections of the water-vascular system in numerous instances, I am in a position to speak pretty confidently in regard to many of those points which have hitherto been regarded as doubtful. It is quite clear that the ancient view of Mehlis, as to the termination of this system by a caudal outlet, is correct; but it is not quite so evident that the ultimate cœcal ends of the excretory vessels have any connection with the so-called calcareous corpuscles. These bodies, indeed, do not appear to have any existence in the common fluke and its allies, although they have been found so abundant by Wagener in the trematode Holostomata. Possibly they may occur here in a very rudimentary or incomplete state; but if we subject any one of the ultimate cœcal ends of these vessels to high magnifying powers, we invariably find (in the fresh condition) the extremity of the tube occupied by a quantity of highly refracting yellowish corpuscles (the largest measuring $\frac{1}{3570}''$), looking very like fat globules. It is difficult to see any connection between these bodies and the calcareous corpuscles, especially as they do not exhibit the same phenomena under the addition of acid reagents. These highly refracting corpuscles vary very much in size, some of them, according to Leuckart, attaining a diameter of $\frac{1}{3570}''$. I find the larger ones to measure fully $\frac{1}{3333}''$.

In addition to these corpuscles, the vessels include a more or less abundant, transparent, watery fluid, in which the above-mentioned bodies float freely. It is not improbable that the ducts contain vibratile cilia, but I am not aware that they have been actually demonstrated in Fasciola, although they have been seen in the excretory system of other entozoa. The walls of the vessels, according to my own observation, consist of a single layer of transparent polygonal cells, specialised apparently from the ordinary parenchyma of the body. Certainly this excretory system cannot be regarded as a true circulatory apparatus, for the median trunk is totally unlike the contractile dorsal vessel of leeches and other annelids. A true blood-system is entirely wanting.

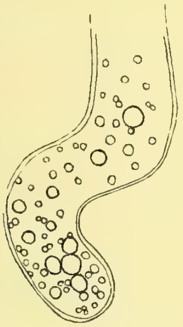

FIG. 35.—Closed extremity of a water-vessel in *Fasciola hepatica* (× 260 diam.).—Original.

Besides the foregoing structures, Leuckart mentions the occurrence of another set of organs, which he calls cutaneous glands. They form a thick layer of cells with granular contents, varying from $\frac{1}{1250}''$ to $\frac{1}{830}''$ in breadth, and having a distinct, bright nucleus measuring $\frac{1}{2272}''$ in diameter. This layer is freely traversed by the terminal twigs of the aquiferous system, with which Leuckart thinks they may have some connection, although this union could not be actually demonstrated.

The most important, however, of all the internal organs of the hermaphroditic liver fluke are those concerned in the reproductive process. The outlets of these organs are placed side by side, in the middle line, and a little above the ventral sucker; the male apparatus terminating externally by a conspicuous intromittent organ or penis. This appendage is very commonly found protruded in the dead fluke, being always, in this case, more or less curved upon itself in a spiral manner. The organ itself consists of layers of longitudinal and transverse muscular fibres, surrounding a central mass of highly contractile parenchymatous cellules. Its extremity is lobed and imperforate, the included seminal duct *(ductus ejaculatorius)* terminating, according to Simonds, on its surface, near a point corresponding with the commencement of the lower third of the organ. Not having myself seen the alleged opening at the extremity of the organ, I am inclined to believe that Mr. Simonds' description of the generative appendage is, in this particular, more correct than any other that has appeared. In the retracted condition the penis is lodged within a distinct pouch or sac, its position being indicated only by a triangular depression and slight fulness of the surrounding parts. The integument of the penis is manifestly a production of the ordinary epidermis and cuticular covering, and like the latter is furnished with a number of minute spines. These frequently drop off, causing the organ to appear naked. The pouch or cirrhus-sac not only encloses a penis, during its retractation, but also a large flask-shaped seminal receptacle, in which one may observe a dense granular mass, consisting of multitudes of spermatozoa. At the lower part of the sac the *receptaculum seminis* receives the two *vasa deferentia,* which combine to form a single channel near their point of junction with the receptacle (Plate XI., Fig. 6). These filamentary ducts are of unequal length, and distinct throughout the greater part of their course, which commences, in either case, at a point where the seminiferous tubes of the testes coalesce. In this animal the testes are exceedingly peculiar; for instead of forming two large globular masses (as usually happens in the flukes), they are split up, as it were, into a multitude of very narrow vermiform tubes, being spread out so as to occupy at least one half of the interior of the animal.

The female organs are not less complicated. The vaginal outlet is placed a little to the left of the middle line, immediately above the margin of the ventral sucker. According to Kuchenmeister, it has a common opening with the penis, but this error has been corrected by Simonds, and even by Kuchenmeister himself in a passage which he quotes from Mehlis. The vagina is probably capable of very great dilation, but in its ordinary condition it is much narrower than the extremity of the intromittent organ; the aperture is so narrow, indeed, that it appears to be only capable of giving exit to a single ovum at a time. At a short distance from the orifice it widens out to form the true uterus, or uterine canal, which here consists of a long tube coiled upon itself, and containing in its interior a large number of brownish yellow eggs. From the ventral aspect this folded tube is easily recognized by the naked eye, forming a conspicuous brown-coloured rosette, which is placed directly below and behind the ventral sucker. Towards the vaginal end the uterine tube looks more highly coloured than at its oviducal extremity, in consequence of the contained eggs being more completely developed in this situation. This is owing also to the circumstance that great numbers of the eggs are collected together at one spot, distending the tube very considerably. The breadth of the canal will thus be found to vary from $\frac{1}{50}''$ to $\frac{1}{17}''$ in transverse diameter. Towards the ovarian end of the canal the uterus becomes rather suddenly narrowed into a short oviduct, in which the eggs are seen lying, incompletely developed and very pale-coloured. This duct communicates in front with the ovary, a heart-shaped organ, which receives at its broad or lower end the united extremities of two other ducts, which meet and anastomose at this point. These two ducts are the primary, main, vitelligene canals, and, from their dark-coloured contents, are usually very well marked and visible to the naked eye. They form together a continuous transverse line of demarcation, which somewhat roughly indicates the limits of the superior third of the body. In some instances, one or other of these tubes is bifurcated at some part of its course, but usually both of them pass in a straight line to a point corresponding with the limiting border of the testicular filaments, one to the right and the other to the left. In this situation they divide abruptly into two secondary channels, which also, on their part, each form a continuous line, placed at right angles with the primary canal, and parallel with the lateral margins of the body of the animal. Throughout their entire course the secondary canals give off tertiary branches, which pass outwards at a right angle to the former, and these again subdivide into minute twigs, which ultimately terminate in bundles of grape-like cœcal extremities. These enlarged globular ends constitute the so-called yelk-sacs, and all of them, combined together, form the vitelligene glands which extend backwards from the anterior part of the body—on a line with the ventral sucker—to the caudal extremity. As shown in the drawing (Plate XI., Fig. 1) they form a brownish-coloured horseshoe-shaped mass, completely embracing the reproductive organs, and filling up the central space of the lower third of the body, where the latter is not occupied by the testes. In this situation the two vitelligene masses do not coalesce, but are separated from each other, in the middle line, by a very narrow space set apart for the passage of the main canal of the water-vascular system. The yelk-sacs themselves form little dots barely visible to the naked eye, from $\frac{1}{555}''$ to $\frac{1}{200}''$, and contain in their interior numerous yelk-globules, or nucleated cellules, measuring about the $\frac{1}{3125}$ of an inch in diameter, the nucleus being $\frac{1}{8333}''$.

A nervous system has been described by Mehlis, Blanchard, and especially by Leuckart. It consists, firstly, of a pair of cephalic ganglia, situated in the space between the oral sucker and the pharynx, but separated from the latter by a thin layer of connective tissue. The ganglia give off two main branches or lateral nerves, which run downwards in a parallel manner, near the middle line of the body, and give off secondary branches to the sides of the animal. According to Leuckart, the lateral ganglia described by Blanchard do not exist. The cephalic ganglia, however, give off branches to the oral sucker and sides of the head, some of these twigs being probably concerned with the sense of touch. A thin commisural filament connects the two ganglia above the pharynx, but throughout the rest of the system the two divisions remain distinct.

Comparison with *Fasciola gigantea.*—Before proceeding to the consideration of the eggs and the development of their contents into the embryonic and higher larval trematode conditions, I would direct attention to the differences subsisting between the common liver-fluke and a similar allied form which I discovered some years since in the liver of a giraffe. Two examples of the species in question are represented in the frontispiece.* If the actual appearances presented by the water-vascular and digestive systems, respectively, in the frontispiece be compared with the diagrammatic representation of the same systems given in figs. 2 and 3 of Plate XI., it will be seen that they correspond in the main, but in the fluke from the giraffe the number of secondary branches rising from the central longitudinal main stems are, in either system, more numerous than obtains in the common fluke. Moreover, independent of the remarkable disparity of size, some of the specimens of *Fasciola gigantea* being fully three inches long, the relative form of the two species is very different. In all the examples of *F. hepatica* the lower half of the body is gradually narrowed towards the caudal point, presenting a more or less V-shaped outline, whilst in *F. gigantea* the narrowing only commences at a very short distance from the tail end, which in some instances is not only not pointed, but bluntly curved, or even truncated. In certain cases, the position of the *foramen caudale* is significantly marked by a notch at or near the centre of the termination of the tail. Many other minor differences exist, which it is unnecessary to insist upon, especially as they are, in the main, dependent upon those already referred to; but sufficient has, I think, been advanced to show that the notion entertained by Van Beneden, namely, that these two forms are specifically identical, is incorrect. In this view, I am glad to find I have the support of so discriminating an authority as Leuckart, who arrived at the same conclusion from an examination of two specimens which were much smaller than those from which the figures in the frontispiece have been taken.*

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* The left-hand figure represents the digestive system injected with artificially prepared ultra-marine; that on the right displaying the water-vascular system injected with vermilion. These drawings are from preparations in the author's possession.

Special Structures.—Before passing to the consideration of the development of the common fluke, I may refer to one or two other structural peculiarities which I have hitherto omitted to mention. In addition to the cutaneous system of glands, Leuckart mentions the occurrence of a few equally distinct isolated gland-elements in the neighbourhood of the pharynx, as well as others imbedded between the muscles of the pharynx and also between the muscles of the oral sucker. The cells are filled with coarsely-granular contents, and also display a highly refracting nucleus. They are thought to possess a salivary function. According to the same authority, there is also a separate, thin-walled, muscular sac, forming a distinct and independent organ, though intimately connected with the true pharynx. It appears to be a sort of diverticulum, for Leuckart has occasionally seen it filled with the ordinary intestinal contents. As a solitary sac, it appears to be peculiar to *Fasciola hepatica*, but Pagenstecher and Walter have described two similar organs, one on either side of the pharynx, in *Amphistoma subclavatum*. By the latter authority they are regarded as salivary glands, but Pagenstecher looks upon them as supplementary sucking organs.

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* Without mentioning my name, MM. Paul Gervais and P. J. Van Beneden make the following strange statement in their "Zoologie Médicale," Tom. ii., p. 201, Paris, 1858):—"Le Distome trouvé, en Europe, dans le foie d'une Girafe, et qui a été décrit comme une autre espèce, n'est aussi qu'un *Distoma hepaticum.*" As a "set off" against this, it is only due to myself to add Leuckart's comment ("Die Menschlichen Parasiten. Erster Band." Lief. 3, s. 530), which stands as follows:—"Das von *Spencer Cobbold* aus den Gallengängen de Giraffe beschriebene *Dist. giganteum*, das ich durch die Freundlichkeit seines Entdeckers in zwei Exemplaren untersuchen konnte, ist in der That eine eigene Species und keineswegs, wie *Van Beneden* angiebt, mit dem gemeinen *Dist. hepaticum* identisch."

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CHAPTER II.

FASCIOLA HEPATICA.

Development of *Fasciola hepatica*—Eggs and ciliated embryos—Injurious effects of the liver-fluke upon man and animals—Symptoms produced by the Rot—Pathological appearances—Treatment—Summary.

WITHOUT attempting to enter into such minute details as would extend this work beyond the proper limits, I shall here briefly indicate the extent of our knowledge regarding the developmental process so far as it concerns the earlier stages of the species under consideration; omitting all hypothetical views concerning the later stages, because it is highly probable that we shall soon be in possession of most of the principal facts relating to the phenomena of the intermediate and later stages of development, as they occur in this trematode.

Development.—Stated briefly, the formation of the ova takes place in this manner. Yelk globules pass down the various vitelligene ducts into the main lateral and transverse efferent canals, until they arrive at the point of union between these passages. Near this situation, in an enlargement of the duct specially set apart for the purpose, and where it is joined by a short germigene duct, the globules congregate and surround the individual germinal vesicles coming from the ovary. At this spot, therefore, we have the earliest stage of egg-formation prior to the act of impregnation, which latter function is accomplished by the union of the fine thread-like spermatozoa almost at the same locality, but a little lower down. The free seminal elements themselves form extremely delicate threads, of an irregularly spiral form, and measuring the $\frac{1}{277}$ of an inch in their long diameter. Below the point in question the extreme upper end of the oviduct is developed into a special pouch-like organ, known as the posterior seminal vesicle of Von Siebold. In this *receptaculum seminis* the threads lie coiled together *en masse*, and appear to perform the very act of impregnation as the egg-germs pass downwards into the commencement of the oviduct. Having once arrived at this situation, the first envelope of the egg is developed from a secretion furnished by a special shell-gland, and during the passage of the ovum along the oviduct, into which it has now entered, a second finer shell is formed upon the first. According to Leuckart, the horny chitinous secretion subsequently deposited on the outer shell-membrane is derived from another special set of chitine-secreting gland-cells, lining the oviducal canal. The same authority adds, " Both the membranes refract light highly, but they present a different hue. The inner one being green and the outer one of a reddish tint, the usual yellow colour of the egg undoubtedly owes its origin to the mixture of these two colours." This also accounts for the marked differences in the degree of colouring observed according to their situation in the continuous oviducal and uterine canal. Pale and almost colourless at first, it is only when they have reached the central uterine passage that they have finally acquired their full, bright, brownish-yellow colouring.

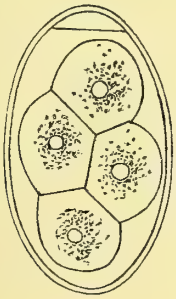

FIG. 36.—Egg of *Fasciola hepatica* in an early stage of yelk-segmentation (× 280 diam.).—Original.

At the time of their highest uterine development or period of departure from the maternal organs, the eggs display an average longitudinal diameter of $\frac{1}{180}''$, whilst their greatest transversal measurement is about $\frac{1}{270}''$. They are, therefore, of no inconsiderable size, although, as is estimated by Leuckart, the uterus of a full-grown fluke may contain as many as 45,000 separate ova, at any one given time. When ready for expulsion the contents of the ova display an irregular granular matrix, in which a number of variously-sized oil-like globules are conspicuous, the whole contents being surrounded by a thin yelk-membrane. According to my own observations made on ova placed in water (January 6, 1863), the contents soon afterwards acquire a more definite shape, but did not arrive at an imperfect stage of embryonic development until the expiration of about six weeks (March 16). Leuckart, however, has watched these changes more fully, and has traced them much further than myself. He states, as a general proposition, first, that "the eggs of the liver-fluke continue their development outside the maternal body in water, each finally secreting an embryo, which, after the manner of other distomes, swims about freely by the assistance of a uniformly-developed, ciliated covering."* Distinct peripheral cells having been formed out of the contained granular mass, the embryo first makes its appearance in the form of a more or less oval, centrally-placed, well-defined body. As growth proceeds, the peripheral cells break down, their place being occupied by the characteristic oil-like yelk globules, which assume every degree of size, and by a gradual coalescence ultimately form a transparent mass almost as large as the embryo itself. After a while, the embryonic body elongates and displays traces of segmentation, in which stage it thus exhibits an anterior section capped by a small papillary eminence, a cephalic or second segment supporting a clearly-defined pigment spot, or eye, in the form of a cross, and a third or body segment constituting one half of the entire embryo. Until water had been permitted to gain access to the interior of the shell,

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* "Die Menschlichen Parasiten," s. 564.

Leuckart could not clearly recognize the existence of a ciliated covering, but on breaking the shell-walls the ingress of water soon revealed the presence of a long wavy line surrounding the entire body. In an earlier stage I have myself observed distinct appearances of segmentation of the embryo as well as other co-ordinating phenomena precisely similar to those which Leuckart so minutely describes. I was much puzzled, however, with certain appearances which these eggs displayed on being broken up; for along with the embryo there escaped a number of amœboid bodies, which moved about actively. On showing my figures of them to Leuckart, he decided that they were parasitic confervoid zoospores, being, in all respects, similar to those he had himself seen and described as referable to the genus *Chytridium.*

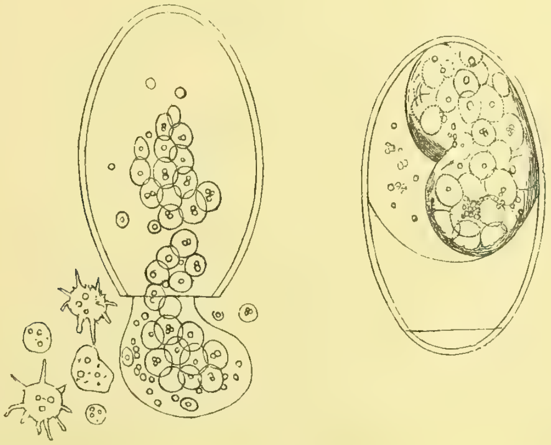

Fig. 37.—Eggs of *Fasciola hepatica,* containing incompletely developed embryos (× 300 diam.).—Original.

The structure of the embryo at the time of its escape from the egg-coverings is exceedingly simple. It has the form of a long cone inverted, the anterior extremity being flatly convex or almost truncate, with a central proboscis-like papilla, devoid, apparently, of cilia. The tail is bluntly pointed. The general ciliated covering rests on a well-defined, finely granular epidermis, the latter being succeeded by a thick peripheral layer of large nucleated cells, measuring individually $\frac{1}{2500}''$. The epidermis has a thickness of $\frac{1}{6250}''$. In the central parenchymatous mass no internal organs are distinguishable, but Leuckart observed faint indications of a canal toward the hinder part, the caudal extremity sometimes displaying, he thought, evidences of a cleft, as if there were an opening.

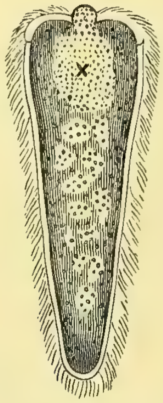

FIG. 38.—Ciliated free swimming embryo of *Fasciola hepatica*.—Leuckart.

As long as the ciliated covering remains intact, the embryo, like other animalcules, displays great activity, whirling round and round on its own axis, and also describing gyrations and circles in the water of different degrees of range, the latter movements being accomplished by bending the body upon itself to a greater or lesser curvature. We have seen *Stentor* and other infusoria exhibiting the same behaviour, and, as Leuckart observes, with his newly-discovered embryo, when these creatures knock against any obstruction, they pause after the blow, as if to consider the nature of the substance they have touched. In the case of the fluke embryo the ciliated covering eventually falls off, when the embryo re-assumes a more or less oval figure, at the same time changing its swimming mode of progression for the less dignified method of creeping. In the free ciliated condition the embryo of the common liver-fluke measures, according to Leuckart, $\frac{1}{190}''$ in length, the anterior broad end being $\frac{1}{500}''$. The cilia have a longitudinal measurement of $\frac{1}{1388}''$.

Up to the time at which I write, the subsequent changes which the embryo of *Fasciola hepatica* undergoes are not clearly defined. Moulinie and others have referred to certain of the Cercariæ, and the higher forms of trematode larvæ as the young of our fluke, but it cannot yet be positively asserted that we know the higher larval conditions of this parasite. Undoubtedly, we may, by inference, form a tolerably accurate notion of the ulterior changes which our embryo undergoes before it arrives at the true distome-type of structure; but in doing this we can only form our general conclusions from data furnished by the history of the development of other well-known species. The course of development usually pursued has already been illustrated in the case of *Distoma militare* in the early part of this work (pp. 23—32), where I have also recorded Pagenstecher's conclusions in regard to the development of trematode larvæ in general. At this point, therefore, I shall quit the subject of fluke development, only referring to it again when offering a final brief *résumé* of the principal facts bearing upon the origin, development, and destiny of the species under consideration.

Injurious Effects upon Man.—Though of comparatively rare occurrence in the human body, the common liver-fluke is, in an indirect manner, extremely injurious to man. By its prevalence in the lower animals it cuts off a large supply of healthy food, at the same time producing a quantity of meat unfit for the market, but which, nevertheless, is largely eaten by our poorer inhabitants. Even the odour arising from the diseased condition of the animal's flesh is not without its baneful effects, and in one instance, at least, it appears to have been the immediate cause of death. In the month of August, 1854, says Mr. Simonds, in his admirable treatise on the Rot, "a person of intemperate habits, following the occupation of a country butcher, was employed in skinning and dressing a number of rotten sheep on the premises of a farmer in the county of Norfolk. The sheep were necessarily opened when *warm*, and while he was so engaged, he complained greatly of the sickening smell. The same evening he was attacked with choleraic disease, and two days afterwards was a corpse."* This case is highly instructive, and when taken in connection with the well-known fact that animals affected with the disease putrify very rapidly, it clearly points to the necessity of removing slaughter-houses far away from densely populated localities.

But, as remarked in the outset of this article, the *Fasciola hepatica* has also been several times known to gain access to the human body. Altogether—excepting the instances mentioned by Chabert, which I regard as spurious—some fifteen instances have been recorded, but in Leuckart's opinion five only are certain, four others being considered probable. A careful record of these instances is given by Davaine in his elaborate work, along with other cases which must for ever remain doubtful.† The satisfactory instances are those recorded by Duval, Frank, Partridge, Giesker, and Dionis ; the scarcely less probable ones being those noticed by Pallas, Fontassin, Harris, and Fox.‡ In my opinion, the two last-named cases are entirely satisfactory, and it is, at least, quite certain that the flukes transmitted by these gentlemen to Professors Busk and Owen could be referred to no other species of distome. The cases recorded by Brera and Treutler are doubtful, whilst that of Mehlis is regarded as altogether fictitious. A more probable instance is the one described by Biermer and Lambl, in the "Prager Vierteljahrschrift," for 1849. The cases of Borel, Bidloo, and Malpighi also rest on insufficient data. On the whole, however, it is quite evident that this parasite is liable to invade man, and there cannot be a shadow of doubt that instances have occurred where its presence has been overlooked, and therefore unrecorded. The rarity of its occurrence, however, is sufficiently explained by the circumstance, that man in a civilized condition can seldom have occasion, either accidentally or otherwise, to swallow the intermediate molluscan hosts in which the higher larvæ of this parasite probably dwell. The circumstance that the fluke has several times been found in abscesses beneath the skin, seems to me to indicate that the animal in its highest larval state possesses a special boring apparatus, such, for example, as we find in the case of *Cercaria ornata.*

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* See Simonds, in the Bibliography.

† "Traité des Entozoaires," p. 251, *et seq.* See also Leuckart's work, p. 575.

‡ To these may also be added the case recently recorded by Dr. H. V. Carter in the "Bombay Medical and Physical Society's Transactions," for 1862.—See Bibliography.

Injurious Effects on Animals.—It is well known that the liver-fluke is extremely destructive, carrying off in England alone some tens and even hundreds of thousands of sheep annually, besides afflicting in a less degree our larger cattle. A writer in the Edinburgh "Veterinary Review," for 1861, says this "scourge of the ovine race has occasionally reduced the number of sheep so much as to materially enhance the price of healthy animals. For instance, in the season of 1830-31, the estimated deaths of sheep from *rot* was between 1,000,000 and 2,000,000. By supplying turnip, oleaginous cakes, and grain, sheep partially affected can be fattened; and those not affected can be kept sound by a limited daily allowance of one or other of these foods." Supposing the number to have been 1,500,000, this would represent a sum of something like £4,000,000 sterling; consequently, as I have before remarked, the disease cannot fail to prove highly prejudicial to our social interests. Every year a large number of sheep perish, but the endemic is much more strongly pronounced in some years than in others. The disease thus produced is variously named in different countries, and also in different parts of the same country. Thus in England it is now most commonly called, simply, the *rot;* but in Devonshire, Dorsetshire, and Cornwall, it is called the *coathe;* whilst in Somersetshire and the western part of England generally, it is known as the *bane* (Simonds). The terms *water-rot* and *fluke-rot* are of course synonymous. In France the disease is vulgarly termed *pourriture,* but the name generally employed, in books, is *cachexie aqueuse.* In Germany the disorder is called *Egelseuche,* which, literally rendered, means the liver-leech plague; in systematic works, however, it is emphatically denominated *die Leberkrankheit*, or *Fäule*.

As instances of its disastrous effects upon the revenues of agriculturists, we may cite the statements of Davaine, as succinctly quoted by Leuckart, and also individual cases recorded by Simonds. "In the neighbourhood of Arles alone, during the year 1812, no less than 300,000 sheep perished, and at Nimes and Montpellier 90,000. In the inner departments, during the epidemic of the years 1853-54, many cattle-breeders lost a fourth, a third, and even three-fourths of their flocks." On the same score, our English authority furnishes a variety of painful cases. Thus, on the estate of Mr. Cramp, of the Isle of Thanet, the *rot epidemic* of 1824 "swept away £3000 worth of his sheep in less than three months, compelling him to give up his farm." Scores of cases are on record where our English farmers have individually lost three, four, five, six, seven, and even eight hundred sheep in a single season; and many agriculturists have thus become completely ruined.

Remarkable periodic outbreaks of this disease are recorded by Simonds as occurring in England in the successive years of 1809, '16, '24, '30, '53, and '60; whilst, for France, Davaine mentions 1809, '12, '16, '17, '20, '29, '30, '53, and '54 as the most remarkable years. It would be interesting to know how far these outbreaks tally with the similar outbreaks which have occurred in Holland, Germany, and other European districts; for, even here, we perceive that the disease was prevalent during four separate years in France and England at one and the same time. This, indeed, is no more than we would naturally expect, considering that the extent of the development of the larval forms must, in a great measure, be dependent upon atmospheric conditions. A warm and moist season would alike prove beneficial to the development of the larvæ and their intermediate molluscan hosts. Their numbers would also multiply enormously; for, as Pagenstecher has shown, the degree of non-sexual production of trematode larvæ within their sporocysts is materially affected by atmospheric changes. On the other hand, a fine, dry, open season, will tend to check the growth and wanderings of the larvæ, and thus render the flocks comparatively secure.

Considerations like these sufficiently explain many of the crude theories which were early propagated concerning the causes of this disease, and in particular, the very generally prevalent notion that water, and water alone, was the true source of the disease. Intelligent cattle-breeders and agriculturists have all along observed that the *rot* was particularly virulent after long-continued wet weather, and more especially so, when there had been a succession of wet seasons. Co-ordinating with these facts, they likewise noticed that the flocks grazing in low pastures and marshy districts were much more liable to invasion than those sheep which pastured on higher and drier grounds, but a note-worthy exception occurred in the case of those flocks feeding in the salt-water marshes of our eastern shores. The latter circumstance has suggested the common practice of mixing salt with the food of sheep and cattle, both as a preventive and curative agent; and there can be little doubt that this remedy has been attended with more or less satisfactory results. The intelligible explanation of the good effected by this mode of treatment we shall find to be intimately associated with a correct understanding of the genetic relations of the entozoon in question, for it is tolerably certain that the larvæ of *Fasciola hepatica* exist only in the bodies of fresh water snails and small aquatic animalcules.

At the present time we are almost in a position to affirm that, ere long, all the main facts relating to the origin and production of the rot-disease will be satisfactorily brought to light. In the meantime, however, we beg to inform estate owners, agriculturists, sheep-farmers, stock-masters, and all other parties interested in the welfare of flocks and in the production of cheap and wholesome food, that a true solution of this important economic question, in so far as it relates to the production of healthy meat, can only be obtained by the further prosecution of our experimental researches.

In this attitude only can we ultimately hope to achieve a certain knowledge of the means of preventing, if not of entirely eradicating, this fearful disease; and the writer confesses that it seems to him strange that the cost of these necessary experiments should hitherto, in this country at least, have exclusively rested with those who have given much time, aided by such talents as they may possess, to practically scientific inquiries. On independent grounds he has himself, year by year, sought to throw light upon the origin and development of the various internal parasites which either annoy or destroy our valuable animals; and as, in some instances, these experiments have proved eminently instructive, he cannot avoid expressing his thanks to the Association which has aided him in these inquiries.*

Those who desire to know what has been doing in other lands towards the elucidation of this important subject should, in particular, consult Davaine and Leuckart's works, already quoted, as well as the Treatise, "De la Reproduction chez les Trématodes endo-parasites," par J. J. Moulinié. "Extrait du Tome III. des Mémoires de l'Institut Génévois;" and also the excellent helminthological memoir by Dr. H. A. Pagenstecher, of Heidelberg, entitled "Trematodenlarven und Trematoden," at the close of which the author appends a note referring to the work of Moulinié, finally adding, "We are encouraged again to take up our hitherto fruitless searchings among land-snails, and we hope, with M. Moulinié, that the next steps in this direction will clear up the history of the development of *Distoma hepaticum*." In this desire I heartily concur.

Symptoms produced by the Rot.—When the disease has far advanced, it is easy to know a rotten sheep, not only by its very look, but still more convincingly, as I have myself frequently tested, by slightly pressing the hand over the region of the loins. In this region the diseased animal is particularly weak, and the pressure immediately causes him to wince, at the same time there is communicated to the hand a yielding sensation totally unlike the firm resistance which one meets with when running the hand down the spine of a sound sheep. In bad cases there is a visible hollowness of the back, associated with a corresponding pendulous condition of the abdomen, and a general emaciation of the body. The spine sticks out prominently, the gait of the animal is feeble, its whole appearance being dull, dejected, and melancholy in the extreme. "The general surface of the skin," says Professor Simonds, "loses its ruddy hue, and becomes deficient of the unctuous secretion which in health belongs to it. This renders the wool harsh and dry, and leads also to its easy separation from the follicles. A dry, scaly state of the skin on the inner parts of the thighs, particularly where it is uncovered with either wool or hair, is likewise early to be recognized." In less advanced cases, the same authority observes, "an examination of the eye will materially assist in determining the question of disease. If the lids are everted, the *membrana nictitans* being pressed forward, it will be found that in the early stages of the malady—and especially if the animal has been excited by being driven a short distance—the vessels of the conjunctiva are turgid with pale or yellowish-coloured blood, and that the whole part has a peculiar moist or watery appearance. Later on, the same vessels are blanched and scarcely to be recognized, excepting, perhaps, one or two, which present a similar watery condition, or are turgid with dark-coloured blood." Some other symptoms might be mentioned, but the above are sufficiently numerous and thoroughly characteristic.

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* See "Report of British Association" for 1862.

Pathological Appearances.—On cutting up a thoroughly rotten sheep the appearances which present themselves to the scientific pathologist are perhaps fully as striking as they are to the butcher himself. One instantly notices the wasted, flabby, watery condition of all the tissues, and a total absence of that fresh, firm, carneous look which so distinctively characterizes the flesh in a state of health. Not only is the rigidity and firm consistency of the muscles altogether wanting, but these structures have lost that deep reddish colour which normally exists. When the abdominal cavity is opened a more or less abundant, clear, limpid, or yellowish fluid will make its escape, and the entire visceral contents will, at the same time, display a remarkably blanched aspect. These pathological changes are also shared by the important organ especially affected, namely, the liver. This gland has lost its general plumpness, smoothness, and rich, reddish-brown colour, and has become irregularly knotted and uneven both at the surface and the margins; its colouring being either a dirty chocolate brown, more or less strongly pronounced at different parts, or it has a peculiar yellowish tint, which in places is very pale and conspicuous. To the feel it is hard and brawny, and when incised by the scalpel, yields a tough and, in places, a very gritty sensation. On opening the gall-ducts a dark, thick, grumous, biliary secretion oozes slowly out, together with several distomes, which, if not dead, slowly curve upon themselves, and roll up like a slip of heated parchment. On further slitting open the biliary passages, they are found distended irregularly at various points, and in certain situations many flukes are massed together, having caused the ducts to form large sacs, in which the parasites are snugly ensconced. The walls of the ducts are also much thickened in places, and hardened by a deposit of coarse calcareous grains on their inner surface. Mr. Simonds says, that "the coats of the *ductus hepaticus*, as also of the *ductus communis choledicus*, are not unfrequently so thick as to be upwards of ten times their normal substance, and, likewise, as hard as to approach the nature of cartilage." Respecting their numbers, the greatest variation exists. The presence of a few flukes in the liver is totally insufficient to cause death; consequently, when a sheep dies from rot, or is killed at a time when the disease has seriously impoverished the animal, then we are sure to find the organ occupied by many dozen, many score, or even several hundred flukes. Thus from a single liver Bidloo obtained 800, Leuwenhoeck about 900, and Dupuy upwards of 1000 specimens. Even the occurrence of large numbers only destroys the animal by slow degrees, and, possibly, without producing much physical suffering, excepting, perhaps, in the later stages. Associated with the above-described appearances, one also not unfrequently finds a few flukes in the intestinal canal, whilst a still more interesting pathological feature is seen in the fact that the bile contained in the liver ducts is loaded with flukes' eggs. In some cases there cannot be less than tens or even hundreds of thousands. Not a few may also be found in the intestinal canal, and in the excreta about to be voided. Occasionally dead specimens become surrounded by inspissated bile, and gritty particles deposited in the liver ducts; thus forming the nuclei of gall stones. Mr. Simonds mentions a remarkable instance, "where the concretion was as large as an ordinary hen's egg, and when broken up was found to contain about a dozen dead flukes. It was lying in a pouch-like cavity of one of the biliary ducts."* Lastly, it need scarcely be added that it is by no means unfrequent to find one or even several other kinds of entozoa co-existing with the Fasciola in the same sheep, the most common form being that of the larval *Echinococcus*.

Treatment.—No one doubts that "prevention is better than cure," and as in the present state of our knowledge we are in a position to offer many suggestions, which, if properly carried out, cannot fail to be of service in checking the fluke malady, it is, in the first instance, desirable to make a few remarks on this head. Moisture being essential to the growth and development of the fluke-larvæ, it is clear that sheep cannot be infected so long as they remain on high and dry grounds, and even in low pastures they can scarcely take the disease so long as they are folded, and fed on hay, turnips, and fodder procured from drier situations. At farmers' meetings I have endeavoured to enforce the expediency of these plans, but, as Mr. Simonds himself has very truly observed, every man depends rather upon his own "preconceived notions of the disease than on any precise scientific information of its nature;" and so it happens that one resumes one's seat with the feeling that, so far as entozoological science is concerned, men appreciate "darkness rather than light." This language may appear harsh, but it is, nevertheless, true. To a certain extent, and partly from other considerations, it must be admitted that some few enlightened agriculturists have adopted those very plans which science pronounces to be correct, and they have, in the end, been amply rewarded for their judicious discernment.

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* In this place one naturally calls to mind the statements of Mr. Garner, who asserts that he has found solitary examples of dead distomata forming the nuclei of pearls, in our common river mussel; a Continental observer has noticed the same thing. See "Reports of the Cambridge Meeting of the British Association for 1862."

As regards the human body, it is obvious that we can only become infested by flukes in one or other of two ways. In their highest larval condition, the parasites either penetrate the skin directly from without, or they are carried into the stomach along with our food, out of which latter viscus they grope their way into the liver. It is highly probable that both these methods of invasion are adopted. In the first case, it is clear that the free larvæ will have been obtained from water used to bathe the person, or from the naked skin being exposed to the surface of moist grass or herbage wherein the larvæ or their molluscan hosts abound. In the second case, they will have been obtained by the individual's having partaken of watercresses, or other field-herbs, in a fresh or unwashen state. Even celery and other market-garden vegetables may harbour the fluke-larvæ, especially in cases where such gardens have been watered by the contents of weedy ponds and stagnant ditches. As other parasites may be conveyed to us in the same way, it behoves all parties concerned in the sale and preparation of vegetable food to subject such matters, in every case, to a thorough *douche* with clean pump or reservoir water. Only after this simple cleansing can the aforesaid vegetable products be declared free from trematode and other helminthic larvæ. It is a noteworthy circumstance that most, if not all, of the cases of *Fasciola hepatica* infesting the human body have occurred in individuals of the lower classes, who would naturally be careless as to the thorough cleansing of water-cresses and other vegetables procured from the garden or the field.

In respect of the method of treatment to be adopted where the parasite has gained access to our bodies, little, of course, need be said. This animal's presence, indeed, could only be diagnosed by the accidentally observed fact that flukes or their ova had been voided; and even then, the exhibition of a purgative would do no more than relieve the intestine of the few specimens which might happen to be lodged in it. Those in the liver would remain untouched; and even mercurial remedies would be of little avail, except in so far as they might increase the flow of healthy bile, and tend to clear the gall passages. Those found in cavities beneath the skin could never be diagnosed, and if they could, would serve no other indications for surgical interference than are supplied by ordinary abscesses themselves.

In like manner, when the malady has become fairly developed in the sheep, internal remedies are of little avail, at least, in view of producing a thorough cure. Palliative treatment may undoubtedly do good, especially in cases where the disease is not very strongly pronounced. The most important thing is the transference of the rot-affected animals to dry ground and good shelter; supplying them, at the same time, with a liberal quantity of manger food, such as beans, peas, and other leguminous seeds. The fodder, of whatever kind, should be frequently changed, and many other hygienic measures adopted, all tending to promote the appetite and general health of the animal. An admixture of salines is a matter of essential importance, especially in cases where the disease is not far advanced. The beneficial effect of salt is one of those few points on which nearly all parties are agreed, and its preservative influence in the case of sheep fed upon salt-water marshland has been previously explained. In regard, however, to the legion of remedies which have from time to time been proposed, all I need here say is, that most of them when fairly tested have been found to fail ignominiously. Every year we hear of the adoption, often with enthusiasm, of new so-called specifics, or of ancient medicines whose employment had long fallen into disuse. Thus, for example, in the April number of the "Journal des Vétérinaires du Midi," for 1860, we find M. Raynaud strongly recommending soot, in doses of from one to three spoonfuls, to be followed up by the administration of a grain of lupin for tonic purposes. In like manner, we have received from France wonderful accounts of the medicinal virtues of a certain fœtid oleaginous compound, the value of which has been lately put to a fair test by our distinguished veterinarian, Professor Simonds. This last-named gentleman having with infinite care and trouble undertaken a series of experiments with the nauseating remedy in question, informs us, in the "Scottish Farmer and Horticulturist," as a result of his inquiries, that he fears "we must conclude that this supposed cure of *rot* in sheep has proved quite ineffective for good in our experience." Finally, in regard to the merits of Mr. Youatt's method of treating the malady, as if it were an ordinary inflammation of the liver, requiring the adoption of bleeding and other sharp, antiphlogistic measures, one can only regard the plan as altogether a mistake. However, those who desire further knowledge on this point should consult the admirable essay by Mr. Simonds, to which I have so frequently had occasion to allude.

Summary.—Correlating all the known data afforded by the experience of our best veterinary authorities, by observant naturalists generally, by my own researches, and by the recent experimental investigations of Continental helminthologists, I may here state in a tentative manner the conclusions to which a due consideration of all these facts inevitably lead. The deductions here recorded may eventually require modification in respect of their minor details; but in the main they will be found substantially correct, and therefore be likely to convey that kind of information which can scarcely fail to interest those more immediately concerned in the preservation of cattle, as well as those also who regard the subject from a wider social point of view. It is even now encouraging to think that when a little more light shall have unveiled all the missing links now wanting to complete the chain of evidence, the promoters of science will more hopefully seek to enlighten those who, in so far as *natural history* knowledge is concerned, are unwisely clinging to the idle "tales of a grandfather." Surely an enlightened public will no longer esteem the vague opinions of a bygone age to be more worthy of credit than the clearly enunciated facts of recent scientific discovery.

1. The *Fasciola hepatica*, or sexually-mature liver-fluke, is especially prevalent in sheep during the spring of the year, at which time it constantly escapes from the alimentary canal of the *host*, and is thus transferred to open pasture-grounds.

2. It has been shown by dissections that the liver of a single sheep may, at any given time, harbour several hundred specimens of the fluke, and it is certain that every mature entozoon will contain many thousands of minute eggs.

3. The escaped flukes do not exhibit powers of locomotion sufficient to prove them capable of undertaking an extended migration, but their movements may subserve the purpose of concealing them within the grass or soft soil where they have fallen. Their habit of coiling upon themselves probably facilitates the expulsion of their eggs.

4. The eggs can only escape from the oviduct of the entozoon one at a time, but there is no doubt whatever that prodigiously large numbers of loose ova are expelled the infested sheep in the same manner as the flukes themselves.

5. By the dispersing agency of winds, rains, insects, feet of cattle, dogs, rabbits, and other animals, and even by man himself, the eggs are carried in various directions, not a few of them ultimately finding their way into pools, ponds, ditches, canals, and running streams.

6. The freed eggs, at the time of their maturity, contain ciliated

embryos, capable of active progression when brought in contact with dew on the blades of grass, rain-drops, pools of water, ponds, and lakes. The prolonged action of moisture without, aided by vigorous movements of the perfected embryo within, serves to loosen the lid-like end of the egg-shell, by the opening of which the animalcule is set free.

7. The ciliated embryo, which is furnished with a solitary X-shaped eye, after a longer or shorter period of activity, loses its ciliated covering, and becomes comparatively inert. It alters its form, and probably soon afterwards gains access to the body of a fresh-water mollusc, or, possibly, into the tissues of a land-snail.

8. Once within the viscera or substance of its so-called *intermediate host*, the non-ciliated larva probably becomes transformed into a large sac, and developes new larvæ within its interior. These sac-like larvæ are called "nurses," or "sporocysts," or, when rather highly organized, "rediæ."

9. The contained nurse progeny or higher trematode larvæ are probably furnished with tails, as in other flukes. When fully developed, they constitute the well-known Cercariæ.

10. The Cercariæ have a tendency to migrate from the bodies of their molluscan hosts, and they are quite capable of an independent existence. During these wanderings in the water, they are occasionally brought in contact with the human body, and in a few instances appear to have succeeded in penetrating the skin.

11. It is not certain whether the Cercariæ are taken into the bodies of quadrupeds when the latter are drinking water or eating solid food, but it is probable that they are passively transferred in either way. It is not unlikely that they are often swallowed while still resident with the bodies of their molluscan hosts.

12. From the digestive organs of sheep or cattle the Cercariæ make their way into the liver, in which new situation they probably part with their tails, and become encysted. This constitutes the so-called *pupa* stage.

13. The pupa, thus encysted for many weeks, or even months, attains a higher organization, at last becoming converted into the sexually mature *Fasciola hepatica.* It gains access to the liver ducts, then passes into the common biliary outlet, and from thence is transferred into the intestinal canal, being finally expelled its vertebrate host in the manner previously described.

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CHAPTER III.

DISTOMA LANCEOLATUM.

Flukes with a simple unbranched intestine—*Distoma lanceolatum*—General and specific characters—Its non-identity with *Fasciola hepatica*—Kichner's interesting case—Leuckart's account of the embryo—*Distoma ophthalmobium*—*D. crassum* and *D. heterophyes*—*Bilharzia hæmatobia*—General and specific characters—Structure and development—Injurious effects on man—*Tetrastoma renale*—*Hexathyridium pinguicola* and *H. venarum*.

So far as is at present known, there are but two species of flukes which display a dendroid or branched digestive apparatus. These have both been described in the foregoing chapters, and, therefore, I now pass to the consideration of those trematodes which have a simple, bifurcated intestine, or, in other words, those species of human parasites legitimately allocated under the generic title of *Distoma*. They are, in short, the distomes properly so called; but as, in the non-systematic part of this work, it is unnecessary to insist on such rigidly-scientific definitions, we shall here continue to speak of the trematodes as distomes or flukes, indifferently, whether we refer to members of the genus *Distoma*, or to those of the allied genera *Fasciola*, *Campula*, *Bilharzia*, and *Hexathyridium*. Those persons who are only acquainted with the human entozoa may be reminded that the family of flukes (*Distomidæ*) embraces a great many other genera than those above indicated, all of which will be found named, and some described, in the systematic part of this treatise.

2. Distoma lanceolatum.

D. lanceolatum, Mehlis; Bucholz; Dujardin; etc.

D. hepaticum, Zeder; Rudolphi; Bremser; etc.

Dicrocœlium lanceolatum, Dujardin; Weinland.
Fasciola hepatica, Block; Jördens; Bosc.
F. lanceolata, Rudolphi; Moquin-Tandon.
Planaria latiuscula, Goeze.

General and Specific Characters.—A small, flat trematode helminth, measuring rather more than the third of an inch in length, and about one line and a-half in breadth, being also especially characterized by its lanceolate form; the widest part of the body corresponds with an imaginary line drawn opposite the spot where the blind intestinal tubes terminate, and from this point, on either side, the width of the animal becomes gradually narrowed towards the extremities; both ends are pointed, but the inferior or caudal one more obtusely than the anterior or oral end; the general surface is smooth throughout, and unarmed; the reproductive orifices are placed in the central line immediately in front of the ventral sucker, and below the point at which the intestine bifurcates; the oral sucker is nearly terminal, and $\frac{1}{50}''$ in breadth, the ventral acetabulum being about the same diameter; the testes form two lobed organs placed one in front of the other in the middle line of the body and directly below the ventral sucker; the uterine canal is remarkably long, forming a series of tolerably regular folds, which occupy the central and hinder parts of the body, reaching almost to the caudal extremity. The vitelligene glands cover a limited space, on either side, near the lateral borders of the animal, the *foramen caudale* communicates with a contractile vesicle, which passes upwards in the form of a central trunk vessel, early dividing into two main branches; these latter reach as far forwards as the œsophageal bulb, opposite which organ they suddenly curve upon themselves, retracing their course for a considerable distance backwards; the digestive canals are slightly widened towards their lower ends, which occupy a line nearly corresponding with the commencement of the lower fourth of the body; the ova are conspicuous within the uterine folds, and gradually pass from a dark-brownish colour in front to a pale-yellow colour behind.

This species, though, comparatively speaking, little known, is by no means of rare occurrence in the sheep and ox. Dujardin constantly met with it in the former of these two ruminants, and he also, in common with Goeze and Bremser, detected it in the pig. Rudolphi observed it in the red deer (*Cervus elaphus*), and Schäffer in the fallow deer (*Cervus dama*). It has also been noticed in the rabbit and hare by Zeder and Bremser, and even in the cat (by Rudolphi and Siebold) according to Dujardin; but, probably, the most common place of abode of this fluke, in the adult condition, is the liver of the ox.

Mehlis was the first to establish the non-identity of this species with the common fluke; a view, which was also shared by Schäffer and Rudolphi, but subsequently abandoned by the latter.

Only three instances of the occurrence of this well-marked form in the human subject are, at present, on record. The first is that of Bucholz, who found a considerable number of these little flukes in the gall-bladder of a prisoner who died from fever at Weimar. The specimens, which are still preserved in the Museum of the University of Jena, have been re-examined by Leuckart, who pronounces them to be certainly referable to *D. lanceolatum*. The second is the case of Chabert, which occurred in France. In this instance a large number of specimens were expelled the intestines of a girl twelve years of age by the administration of empyreumatic oil. The third example is one of comparatively recent date, for the particu-

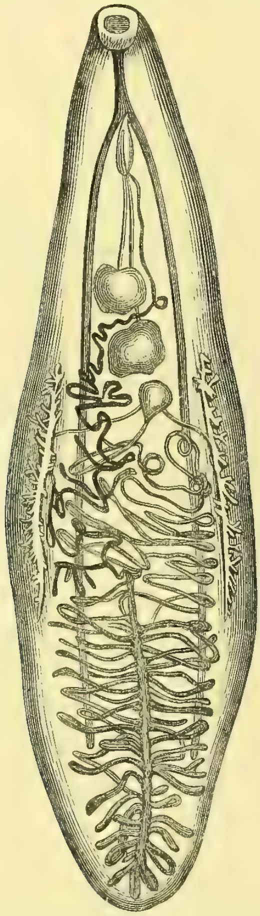

Fig. 39.—Full-grown *Distoma lanceolatum*, showing the reproductive and digestive apparatus; highly magnified.—Blanchard.

lars of which we are indebted to that indefatigable helminthologist Rudolf Leuckart, to whom the case was communicated by Dr. Kichner, of Kaplitz in Bohemia. As this case is highly interesting and instructive, I give an abstract of it, as follows :*—

"Dr. Kichner's patient was a young girl, the daughter of the parish shepherd at Kaplitz, having been accustomed to look after the sheep ever since she was nine years old. The pasture where the animals fed was enclosed by woods, being traversed by two water-dykes, and being, moreover, also supplied by ten little stagnant pools. These reservoirs harboured numerous amphibia and molluscs (such as *Lymnæus* and *Paludina*), and the child often quenched her thirst from the half-putrid water. Probably she also partook of the watercresses growing in the ditches. At length her abdomen became much distended, the limbs emaciated, and her strength declined. Half a year before death she was confined to her bed, being all the while shamefully maltreated by her stepmother. Dr. Kichner only saw her three days before her death, and ascertained that she had complained of pain (for several years) over the region of the liver. A *sectio cadaveris* was ordered by the Government, when (in addition to the external evidences of the cruel violence to which the poor creature had been subjected) it was found that she had an enormously enlarged liver, weighing eleven pounds. The gall-bladder, which was very much contracted and nearly empty, contained eight calculi and forty-seven specimens of the *Distoma lanceolatum*, all of which were sexually mature."

Considering the facts of this singular case, one can have no difficulty in arriving at the conclusion that these parasites were obtained from the girl's swallowing trematode larvæ, either in their free or in their encysted condition. Leuckart says it was not possible to ascertain whether the parasites had any connection with the gall-stones, or whether the two maladies, so to speak, were independent of each other; yet this question might possibly have been solved if the calculi had been broken up, in order to ascertain their structure. It is just possible that dead distomes may have formed their nuclei, and if so, the circumstance would, of course, point to the worms as the original source of the malady.

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* "Die Menschlichen Parasiten." Erst. Bd., s. 608, *et seq.*

Into the minute anatomy of this trematode it is unnecessary to enter at any length, because, in the main, its structure corresponds with that of Fasciola, although great differences obtain in respect of the form and disposition of the internal organs. These have been partly indicated already, but there are still some points worthy of consideration. Thus, in connection with the digestive system, Walter has described a special set of salivary organs. Leuckart, who appears to attribute to them an independent function, says that they are readily visible in the living animal. "They are found in rather considerable numbers, scattered over the front part of the body, and appear in the form of large granular cells (measuring $\frac{1}{676}''$), enclosing a globular nucleus, and each of them terminating in a thin and long filiform excretory duct. All the ducts are directed forwards towards the oral sucker, into which, according to Walter's description, they open in a partly isolated, and partly combined manner." In other particulars the digestive apparatus is simple, the mouth and muscular pharynx being followed by a narrow œsophagus, which divides into two blind intestinal tubes, which become very gradually widened as they approach their inferior limits.

As regards the nervous system, the only distinction worth noticing consists in the more backward position of the commisural filament, which connects the two cephalic ganglia; and even here, according to Leuckart, considerable variation occurs. The excretory system is well developed, and terminates inferiorly in a very conspicuous sac, which latter is usually filled with active molecular particles, and appears to be capable of extrusion. The reproductive organs are, for the most part, easily made out; but except as regards the lobulated and simple form of the testes, the greater number and altered position of the uterine folds, and the very limited extent of the development of the vitelligene glands, there is little which need be added to the general and specific characters previously described.

The development of *Distoma lanceolatum* is, however, a matter of greater importance, especially since our knowledge of its life-changes suggests an interesting comparison between the earlier embryonic stages displayed by the larvæ of different trematode species. It is to Leuckart that we are indebted for most of the facts bearing upon this subject. In the first place, it is especially worthy of notice that the contents of the ova attain a tolerably high degree of embryonic formation before the eggs quit the uterine or oviducal canal of the parent; consequently, it is not improbable that the subsequent larval metamorphoses are accomplished with more rapidity than obtains in the case of Fasciola. It would seem, however, that the embryos do not make their escape from the egg-coverings immediately after the eggs have been deposited by the parent, but, according to the experiences of Leuckart, an interval of a few weeks must elapse. In the early condition, the rudimentary embryo occupies the centre of the egg, and always has its cone-shaped, cephalic end directed towards the upper pole of the shell, or, in other words, to that end which is furnished with the lid-like operculum. In the mature state, whilst still within the uterus, the cone-shaped head is supplied with a ciliated crown. Speaking of its intimate structure, Leuckart says, " It is finely granular, and armed at the tip with a dagger-like spine, which, with the simultaneous displacement of the adjacent granular mass, can be pushed forward and drawn back again." Besides this so-called cephalic granular mass, there are within the embryonic body two other granular masses widely separated from each other, but occupying the posterior half of the embryo. These Leuckart supposes to be the rudiments of a future brood to be developed at the time when the free embryo shall have lost its ciliated swimming apparatus, shall have bored its way by means of the cephalic spine into the tissues of a mollusc, and shall have become metamorphosed into a sac-like larva (Nurse, Sporocyst, or Redia, as the case may be). Whatever be the full significance of these internal developments, we have at least satisfactory evidence that the complete and free embryo is a globe-shaped animalcule, having the anterior third or cephalic end of the body covered with cilia, and armed with a central boring spine. In consequence of this limitation of the ciliated covering, its swimming movements are less vivacious than those of the embryo of *Fasciola hepatica ;* it will, therefore, probably take up its residence in a less active host than that chosen by the embryo of Fasciola, selecting one of those molluscs which either move slowly or are prone to keep at the bottom of the water. The mature eggs have a length of $\frac{1}{625}$ to $\frac{1}{555}$ of an inch, and a breadth of $\frac{1}{833}''$. The long diameter of the free embryo varies from $\frac{1}{990}''$ to $\frac{1}{833}''$, the transverse diameter being $\frac{1}{1562}''$. Whilst the embryos were still in the egg Leuckart could see no ciliary motion ; with most observers, both the ciliary apparatus and the boring spine appear at this stage to have altogether escaped observation.

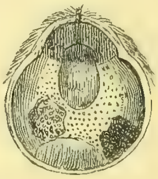

FIG. 40.—Free embryo of *Distoma lanceolatum ;* highly magnified.—Leuckart.

The further transformations of the embryo and larvæ of *Distoma lanceolatum* are not known with certainty, but our conjectures on this score cannot be far removed from the actual truth. We shall probably find that the embryo changes into a Sporocyst, the latter producing, directly or indirectly, a colony of armed cercarian larvæ provided with tails. These higher larval forms may again inhabit molluscs, after a longer or shorter period of active wandering, being subsequently transferred along with their hosts into the intestinal canal of herbivora, and, in a few cases (probably along with watercresses) into the human stomach. Leuckart thinks he has hit upon the juvenile form of *Distoma lanceolatum* in the body of *Planorbis marginatus*, but his feeding experiment to prove this relationship was not thoroughly satisfactory. Future investigation will doubtless reveal all the actual stages through which this and many allied fluke-species pass during their progress upwards from the lowest larval to the highest sexually-mature condition.

3. DISTOMA OPHTHALMOBIUM.

D. ophthalmobium, Diesing; Kuchenmeister; etc.
D. (*lentis*), Von Ammon.
D. oculi-humani, Gescheidt.
Dicrocœlium oculi-humani, Weinland.
? Monostoma lentis, Nordmann; Gescheidt; Diesing; etc.
? Festucaria lentis, Moquin-Tandon.

I here combine the two so-called species of human eye trematodes under one title, without, however, for a moment supposing that we have either in the *Distoma ophthalmobium* of Diesing or the *Monostoma lentis* of Nordmann, a genuine sexually-mature fluke. I think it highly probable that both forms may be the young of one distome; and (as suggested by Leuckart's comparisons in the case of *Distoma ophthalmobium*) it is quite possible they may both of them be referable to the species last described (*D. lanceolatum*). Certainly one has a difficulty in believing that so accurate an observer as Nordmann could have overlooked a ventral sucker, if one were really present; and yet, on the other hand, the remarkable minuteness of the worm may have served to obscure

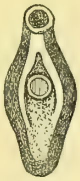

FIG. 41.—The so-called *Distoma ophthalmobium*; considerably magnified.—Von Ammon.

this organ. Similar mistakes have occurred before, as Dujardin and others have pointed out.

In the case of the *Distoma ophthalmobium* Gescheidt found four specimens in the eye of a child five months old, born with lenticular cataract. No one of the examples exceeded half a line in length. They were situated between the lens and its capsule, in which place they could be recognized as so many dark spots on the surface of the lens. From the original description in Von Ammon's "Zeitschrift für Ophthalmologie" we are scarcely warranted in concluding that the specimens were sexually mature. The author speaks of ovaries, but they were "indistinct," and they are not represented in the carefully executed figures given in Von Ammon's writings.* One can scarcely escape the conviction, moreover, that Von Nordmann's *Monostoma lentis* is identical with this worm; and I perceive that Dr. Weinland, of Frankfort, entertains a similar suspicion. Kuchenmeister's idea that this *Monostoma* may be a young *Cysticercus cellulosæ* is not at all convincing; for no one ever heard of eight *Cysticerci* occupying one eye-ball, and much less is it likely that they should occur thus gregariously in the human lens. Trematodes are seldom solitary; and all the circumstances render it probable that the worms extracted by Professor Jüngken, in his case of cataract, were identical with those removed after death from the eye of the little girl who died from infantile atrophy whilst under Von Ammon's care. As just hinted, there were eight specimens in this case, the worms having an average longitudinal measurement of about $\frac{1}{80}$ of an inch. Finally, into speculative questions as to how these parasites came into the eye, one does not care to enter, especially as it would lead us at too great length into the consideration of similar phenomena observable in the lower animals.

4. Distoma crassum.

D. crassum, Busk; Cobbold; Leuckart; etc.

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* "Klinische Darstellungen der Krankheiten des menschlichen Auges," vol. i. t. 12, and vol. iii. t. 14.

D. Buskii, Lankester.
Dicrocœlium Buskii, Weinland.

General and Specific Characters.—A trematode helminth varying from an inch and a half to three inches in length, and having an average breadth of $\frac{5}{8}$ of an inch; especially also characterized by its uniform and considerable thickness, combined with the presence of a "double alimentary canal which is not branched;" the body is pointed in front, and obtusely rounded posteriorly; the integument being smooth and unarmed; the reproductive orifices placed immediately above the ventral sucker: the testes form two bulky, lobed organs, situated below the ventral acetabulum, and disposed in the middle line, one in front of the other; the uterine folds occupy only the front part of the body, the margins of which also display two vitelligene glands, one on either side of the intestinal tube; the excretory organ consists of a central trunk with diverging branches.

This is a good species, and appropriately named; for, although Von Siebold (in Müller's "Archiv" for 1836, p. 234, and in his "Lehrbuch," vol. i. p. 143) refers to a Distome infesting *Hirundo urbica* under this title, he has given no description of the worm. Diesing places Von Siebold's *D. crassum* among his *species inquirendæ*, and it is very probably identical with the *D. maculosum* of Rudolphi. No other instance has occurred since the original fourteen

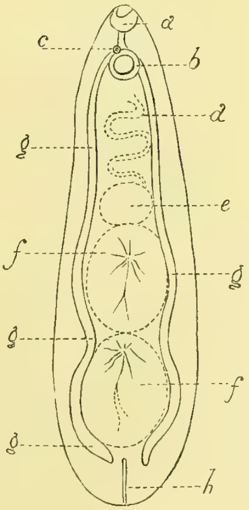

Fig. 42.—Outline drawing of *Distoma crassum*, Busk; the parts not actually visible, in the specimens examined, being indicated by dotted lines; *a*, oral sucker; *b*, acetabulum; *c*, reproductive papilla; *d*, uterine canal; *e*, ovary; *f*, *f*, testes; *g*, *g*, *g*, *g*, intestinal tubes; *h*, aquiferous or excretory canal.—Original.

specimens were discovered by Mr. Busk in the duodenum of a Lascar. From a careful examination of three examples, severally presented by the discoverer to the Museum of the Royal College of Surgeons, the Museum of the Middlesex Hospital Medical College, and to my private collection,* I am satisfied that it is generically distinct from the above; but it is unnecessary to insist further on this distinction, as I have already, in this work, exposed the fallacy of combining the genera *Fasciola* and *Distoma*. In two of the specimens which Mr. Busk injected with mercury, the injection has passed from the digestive into the aquiferous system, which latter, in its arrangements, does not differ materially from that of *Fasciola hepatica*. The original account in Dr. Budd's work on diseases of the liver speaks of a "branched uterine tube." This description, however, is manifestly erroneous, and probably refers to the division of the narrow end of the ovarian tube, where it is joined by the two main ducts which come from the yelk-forming glands on either side of the body.

5. Distoma heterophyes.

D. heterophyes, Von Siebold and Bilharz; Kuchenmeister.
Fasciola heterophyes, Moquin-Tandon.
Dicrocœlium heterophyes, Weinland.

General and Specific Characters.—A minute trematode helminth, measuring only three-fourths of a line in length, and one-fourth of a line in breadth; having an oblong pyriform outline, attenuated in front, and obtusely rounded behind; body compressed throughout, the surface being armed with numerous minute spines, which are particularly conspicuous (under the microscope) towards the head; oral and ventral suckers largely developed, the latter being near the centre of the body, and about twice as large as the former; pharyngeal bulb distinct and separate from the oral sucker, and continued into a long œsophagus, which divides immediately above the ventral acetabulum; intestinal tubes simple, gradually widening below and terminating near the posterior margins; reproductive orifices inconspicuous but evidently placed below and a little to the right of the ventral sucker, at which point they are surrounded by a special accessory organ, resembling a supernumerary sucker; uterine folds numerous and central, communicating with small but conspicuously developed vitelligene glands; testes spherical and placed on the same level in the lower part of the body; ovary distinct; aquiferous system terminating inferiorly in a large oval contractile vesicle, the latter opening externally by a central *foramen caudale*.

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* This specimen is figured in Leuckart's recent work. Erst. Bd., s. 586.

In the month of April, 1851, Dr. Bilharz, of Cairo, discovered this minute parasite in the small intestine of a boy; and on a second occasion he collected several hundred specimens under very similar circumstances. The parts infested displayed a multitude of reddish points, due to the presence of the dark-coloured ova seen in the interior of the worms. Until recently I had not had an opportunity of examining this trematode, and I am, therefore, much indebted to the friendliness of Leuckart for the couple of specimens which he has had the goodness to send me. The close inspection of these has enabled me to follow out his own accurate and extended descriptions, as well as those supplied by antecedent observers. Without, however, recapitulating the distinctive peculiarities indicated in my account of the general characteristics of the worm, it is necessary to draw attention to the very remarkable apparatus surrounding the reproductive orifices. It consists of an irregularly circular disk, measuring $\frac{1}{125}$ of an inch in diameter, and having a thick lipped margin, which supports seventy fish-basket-like horny ribs comparable to the claw-formations seen in the genus Octobothrium. According to Bilharz these ribs give off five little branches from their sides, but Leuckart could not see them in his specimens. The latter finds the

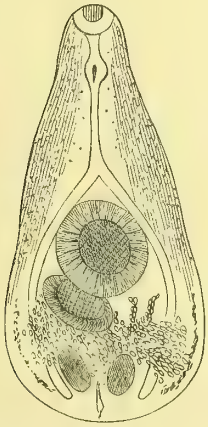

FIG. 43.—*Distoma heterophyes*, Von Siebold; drawn from a specimen supplied by Leuckart (× 60 diam.).—Original.

length of these horny filaments to be $\frac{1}{1250}''$, whilst their breadth is $\frac{1}{3570}''$. On the whole we may regard this organ as a complicated form of "holdfast" designed to facilitate or give efficiency to the sexual act. I may here also state that this structure is by no means unique, for, if I mistake not, it exists in an equally developed degree in the young trematode which Dr. Leared found infesting the heart of a turtle. Leared believed that he had found a true distome, an opinion to which I could not give my assent, seeing that the organ described by him as a "folded, ventral sucker," presented a very different aspect to the genuine oral sucker displayed by the same animal. I am now persuaded that the structure in question, which is, to a certain extent, characteristic of his so-called *Distoma constrictum*, is analogous to the supplementary "holdfast" existing in *Distoma heterophyes*. The opinion also which I then advanced as to the probable source and condition of the parasite, I still see no reason to retract.*

In regard to the anatomy of *D. heterophyes*, I have only further to observe that a special set of glandular organs is situated on either side of the elongated œsophagus, but the connection between these structures and the digestive apparatus is not clearly made out. Leuckart compares them to the so-called salivary glands found in *Distoma lanceolatum*, and says, "The presence of such a glandular apparatus is also indicated by the more ventral position of the oral sucker, and the development of the cephalic margin." The conspicuous contractile vesicle terminating the excretory system is developed to an unusually large extent, exhibiting in its interior multitudes of the well-known active molecular particles. The ova present a rich reddish-brown colour, having a rather broadly oval figure, and measuring $\frac{1}{990}$ of an inch in length, by $\frac{1}{1666}''$ transversely.

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* Dr. Leared's brief description of this parasite is given in the 10th vol. of the "Quarterly Journal of Microscopic Science," p. 169, and is accompanied by an accurate woodcut. New Series, Vol. II. for 1862. He also found in the blood a quantity of ova precisely like those which Mr. Canton had previously described as adhering to the conjunctivæ of turtles' eyes. See a paper in the same Journal for 1861, Vol. I. N. S., p. 40.

6. BILHARZIA HÆMATOBIA.

B. hæmatobia, Cobbold.
B. magna, Cobbold.
Gynæcophorus hæmatobius, Diesing.
Thecosoma hæmatobium, Moquin-Tandon.
Distoma hæmatobium, Bilharz; Kuchenmeister; Moulinié; etc.
Distoma capense, J. Harley.
Schistosoma hæmatobium, Weinland.

General and Specific Characters.—A trematode helminth in which the male and female reproductive organs occur in separate individuals; the male being a cylindrical vermiform worm, measuring only half an inch or rather more in length, whilst the female is filiform, longer, and much narrower than the male, being about four-fifths of an inch from head to tail; in both, the oral and ventral suckers are placed near each other at the front of the body; in the male the suckers measuring $\frac{1}{100}$", in the female $\frac{1}{312}$" in diameter; in either, the reproductive orifice occurs immediately below the ventral acetabulum. The comparatively short, thick, and flattened body of the male is tuberculated and furnished with a *gynæcophoric* canal, extending from a point a little below the ventral sucker to the extremity of the tail; this slit-like cavity being formed by the narrowing and bending inwards of the lateral borders of the animal, the right side being more or less completely overlapped by the left margin of the body; caudal extremity pointed; intestine in the form of two simple blind canals. Female with a cylindrical body measuring only $\frac{1}{312}$ of an inch in thickness in front of the oral sucker; lodged in the gynæcophoric canal of the male during the copulatory act; thickness of the body below the ventral acetabulum being about $\frac{1}{357}$", and at the lower part $\frac{1}{90}$"; surface almost smooth throughout; intestinal canals reunited after a short separation to form a broad, central, spirally twisted tube extending down the middle of the body; vitelligene and germigene canals combining to form a simple oviducal canal, which is continued into a simple uterine tube, finally opening near the lower margin of the ventral sucker; eggs pointed at one end, or by a projecting spine near the hinder pole.

Most helminthologists agree as to the propriety of placing this remarkable trematode in a separate genus, but some dispute has arisen concerning the priority of the various titles which have been proposed. The generic name here adopted is one which I applied to a second species (as I then supposed) discovered by me six months before Diesing communicated his "Revision der Myzelminthen" to the Vienna Academy; but I shall have no objection to employ the title *Gynæcophorus*, proposed by him, if it be generally thought more appropriate. Weinland has expressed to me his willingness to abandon the title *Schistosoma* in favour of *Bilharzia*, which he admits has the priority. Though it is of little consequence which name be retained, the genus itself is one of remarkable interest, not merely in a structural point of view, but also from its prevalence on the borders of the Nile, and also, according to Dr. John Harley, in South Africa and the Mauritius. The first specimens were discovered by Dr. Bilharz, of Cairo, in the portal system of blood-vessels ; and others were subsequently observed by him, Griesinger, Reinhard, and Lautner in the veins of the mesentery, bladder, and other parts, giving rise to a formidable and very common disease. This malady is likewise endemic at the Cape of Good Hope. On the 4th of December, 1857, I discovered a bisexual fluke of this kind in the portal vein of a Sooty Monkey (*Cercopithecus*) which had died at the Zoological Society's menagerie ; and, at the time, as well as for a considerable period since, I believed it to be a species distinct from the worm described by Bilharz. It was accordingly named *Bilharzia magna*. However, whilst I still retain the generic title which was then adopted, I do not now scruple to abandon the specific name, because I am fully inclined to agree with Leuckart that the two forms are identical. The disparity of size which then appeared to be a bar to their identity, does not in reality exist, since Leuckart has shown that some of the specimens derived from human sources were as large as the one which I found in the monkey. In any case the occurrence of this curious genus in the blood-vessels of man and monkeys is highly suggestive. It forms an interesting little circumstance, admirably suited to the taste of those who are on the look-out for affinities of habit between bimana and quadrūmana. The *Cercopithecus fuliginosus* is an African monkey, and, no doubt, in its native haunts it procures the larvæ of *Bilharzia* from the same or from similar sources as those from whence our brethren in Egypt procure their larvæ. Animals lower in the scale do not appear to be liable to attacks from this strangely organized genus of flukes, and, as yet, we are uninformed as to the *hosts* which entertain it in its larval condition.

Up to the time of Bilharz's announcement of the existence of the *Distoma hœmatobium*, so abundantly found by him in the people of Egypt, almost all the flukes were considered to be hermaphroditic, or, in other words, each individual was provided both with male and female organs; the only exception being that of the *Distoma filicolle*, regarded by Rudolphi and Dujardin as a species of Monostoma. So common and numerous, however, is the *Distoma hœmatobium* in Egypt, that Bilharz has expressed his belief that half the grown-up people are infested with it; whilst, in 363 examinations of the human body after death, Griesinger found this entozoon present no less than 117 times. The latter authority also conjectures that the young of *Bilharzia* exist in the waters of the Nile, in the fishes which therein abound, or even in bread, grain, and fruit; but I think it is more probable that the larvæ, in the form of cercariæ, rediæ, and sporocysts, will be found in certain gasteropod molluscs proper to the localities from whence the adult forms have been obtained. Our sooty *host* was, I understood, imported direct from its native country, and was not bred in the Society's gardens; had it been otherwise, it would not, in all probability, have been infested by *Bilharzia.*

The anatomy of *Bilharzia* has been described by the original discoverer, by Kuchenmeister, and especially by Leuckart; but before entering into particulars I take leave to note, in passing, that it is rather singular that Moquin-Tandon should express his belief that the sexes have been mistaken by such competent authorities. The circumstance of the smaller animal being carefully described by them as furnished with uterine ducts, containing eggs, ought to leave no doubt in our minds as to the correctness of the generally-received opinion, unless we have distinct evidence to the contrary. Without entering into minute anatomical details, there are several points which demand consideration. Taking the male first, one cannot fail to notice the horseleech-like aspect of the animal, due to the position of the oral sucker, the disk of which is placed almost on the same level as that of the ventral acetabulum.

The surface of the body is smooth in this region, but immediately below the ventral sucker the epidermis has a minutely tuberculated, warty aspect, which is continued onwards to the point of the tail. The pharynx is apparently unprovided with any special pouch, and there is no œsophageal bulb; the tube bifurcates immediately above the ventral sucker, and these divisions passing on towards the region of the tail, reunite in the central line. The same thing occurs in the female, the point of union taking place much higher up in the body, and producing a long, tortuous, broad, and twisted central canal, which is continued to near the tip of the tail, where it terminates cœcally. The testes appear to consist of several distinct lobes, or small oval organs, which are probably connected to a pair of *vasa deferentia*, opening externally by a single outlet below the ventral sucker. There is no evidence as to the existence either of a seminal pouch, or intromittent organ. In the female the vitelligene glands are situated, one on each side of the central intestinal pouch, whilst the egg-shaped ovary occurs near the point of junction where the intestinal divisions unite. From its posterior margin a germ-duct is given off, which unites with the ducts coming from the vitelligene glands; and these together forming the oviduct are continued forward as a single uterine canal

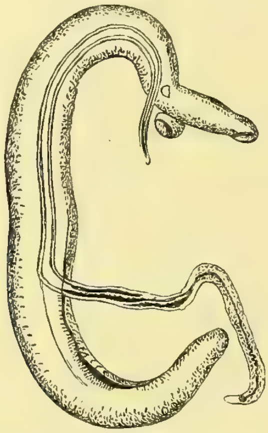

FIG. 44.—*Bilharzia hœmatobia*, Cobbold; male and female, the latter partly enclosed within the gynœcophoric canal. Considerably magnified.—Kuchenmeister.

up to the vaginal outlet, which is directly below the lip of the ventral sucker. From Bilharz and Leuckart I have taken most of these last-named particulars, since my original specimen from the monkey was a male. I have, however, also been enabled to confirm the truth of many other particulars given above, from a careful microscopic examination of the specimens which Leuckart has generously added to my private collection of entozoa. According to Bilharz the aquiferous system is represented by two thin canals, which unite to form a short, tubular "expulsion-sac," anterior to the central point of the tail, where there is probably an open *foramen caudale*.

The eggs of *Bilharzia* have been very carefully examined, and are rather peculiar. In the first place they are somewhat variable in outline, being usually more or less oval, pyriform, or sharply pointed at the hinder pole, but sometimes assuming a simply oblong figure, in which case they are furnished with a spine-like process placed at the side, and a little anterior to the hinder end. Between these two type-forms other slight differences of outline also exist, but in all cases, whilst the eggs are still within the uterine canal, the hinder pole (or, in other words, that end of the egg which is opposed to the one ordinarily provided with an operculum) is directed towards the caudal extremity of the parent's body. Their size is likewise variable, presenting an average longitudinal measurement of about $\frac{1}{200}$ of an inch, and a breadth of $\frac{1}{550}''$. A true operculum does not appear to exist; but Bilharz

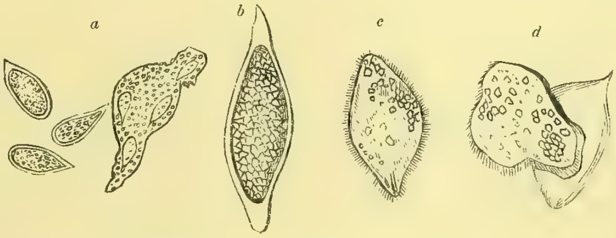

FIG. 45.—Eggs and embryos of *Bilharzia hæmatobia*; *a*, three ova (× 50 diam.), and a portion of mucous membrane with eggs attached (× 25 diam.); *b*, egg with segmented yelk; *c*, free embryo; *d*, ruptured egg, with embryo escaping (× 150 diam).—John Harley.

saw the embryos escaping by a lateral slit near the anterior pole of the shell. Whilst the ova are still within the body of the parent, the embryos develop themselves into minute ciliated animalcules, and after their escape they exhibit lively movements. Many ciliated embryos were found by Griesinger, free, in the intestine of the human subject. According to Bilharz and Leuckart, the embryos measure $\frac{1}{227}''$ in length, and $\frac{1}{676}''$ transversely. They are extremely delicate in structure, being, for the most part, transparent, and containing in their interior a quantity of fine, highly refracting, sarcode globules. At the anterior end, which is more or less pointed, Bilharz observed a double pyriform corpuscular mass, which would probably represent the rudiments of a digestive pouch in the next stage of larval formation. Beyond this point, however, we know nothing as to the precise forms which the larvæ of *Bilharzia* assume ; but it is, of course, highly probable that their sporocystic and cercarian features correspond, in the main, with those displayed by the larvæ of other trematodes.

Injurious Effects upon Man.—The peculiar and formidable helminthiasis produced by this parasite has been thoroughly investigated by Griesinger and Bilharz, and it is, likewise, very fully described in the standard works of Küchenmeister and Leuckart. The prevalence of the disease in Egypt has already been alluded to ; and its principal feature consists in a general disturbance of the uropoietic functions. Diarrhœa and hæmaturia occur in advanced stages of the complaint, being also frequently associated with the so-called Egyptian chlorosis, colicky pains, anæmia, and great prostration of the vital powers. The true source of the disorder, however, is easily overlooked unless a careful microscopic examination be made of the urine and other evacuations. If blood be mixed with these, and there also be a large escape of mucus, a minute inspection of the excreta will scarcely fail to reveal the presence of the characteristic ova of *Bilharzia*. Beside the increase of mucous secretion, there may even be an escape of purulent matter, showing that the disorder has far advanced. The whole constitution eventually becomes undermined; pneumonia often sets in, and death finally ensues. On making *post-mortem* examinations the following pathological facts come to light. In cases where the disease has not very far advanced, minute patches of blood-extravasation present themselves at the mucous surface of the bladder, but in more strongly pronounced cases the patches are larger or even confluent. In some instances there are villous or fungus-like thickenings, ulceration and separation of portions of the mucous membrane, with varying degrees of coloration, according to the amount of the extravasation, which becomes converted into grey, rusty-brown, or black pigment deposits. A gritty or sandy deposit is often superimposed, consisting of the ordinary lithic acid grains mixed with eggs and egg-shells. Bilharz detected ova in the urine, these having probably escaped from the ruptured vesical vessels producing the extravasations and hæmaturia. The lining membranes of the ureters and renal cavities are also more or less affected; the kidneys being frequently enlarged and congested. It must, however, be borne in mind that in all these organs the true seat of the disorder is the blood, which forms the proper habitat of the *Bilharzia;* and this being the case, the worms as well as their escaped eggs may be found in any of the vessels supplying the diseased organs. In one instance, quoted by Leuckart, Griesinger found a number of empty eggs in the left ventricle of the heart, and from this circumstance it was supposed that they might be carried into the various important organs, or even plug up the larger vessels. As before stated, however, the parasites are more particularly prevalent in the vessels of the bladder, mesentery, and portal system. The effects upon the intestinal mucous membrane are, in most respects, similar to those occurring in the urinary organs. Blood extravasations, with thickening, exudation, ulceration, and fungoid projections, appear in and upon the intestinal mucous and submucous tissues; these appearances, of course, being more or less strongly marked according to the degree of infection.

The disease is said to be more virulent in the summer months, which is probably owing to the prevalence of the cercarian larvæ at the spring of the year. It makes very little difference, however, as regards the prospect of cure, which, it need hardly be said, is extremely feeble after the disorder has once fairly set in. Here, indeed, remedies can be of little avail, the only treatment of any value, as regards the general loss of strength, being simply palliative and restorative. The great point to be aimed at is the discovery of the precise source of the higher larvæ of the parasite; and should it eventually turn out that these cercariæ are limited to any one or two particular intermediate hosts, then, certainly, helminthologists would be in a position to show what precautions on the part of the people might secure them from the invasion of this fatal malady. At the same time, they would be able more cogently to enforce a recognition of the truism that "prevention is better than cure."

Dr. John Harley, in his interesting paper on the hæmaturia of the Cape of Good Hope, has suggested the employment of diuretics, but these remedies could be of little avail since the seat of the disorder is in the blood. His *Distoma capense* is certainly identical with *Bilharzia hæmatobia*, and the symptoms produced by it are, for the most part, similar to those above described. A reference to his cases will be found in the Bibliography.

7. TETRASTOMA RENALE.

T. renale, Delle Chiaje; Diesing; Dubini; etc.

The occurrence of this entozoon as a human parasite appears hitherto to have escaped the notice of English zoologists, although discovered by Lucarelli in 1826, and described by Delle Chiaje in 1833. All that we now know of it is due to the original description of Chiaje, from whose "Elmintografia Umana" we learn that it attains a length of five lines, has an oval flattened body, and is furnished with four suckers disposed in a quadrate manner at the caudal extremity. The reproductive orifices are situated near the mouth.

The *Tetrastoma* is stated to infest the tubes of the kidney, but the evidence on which this statement rests is not altogether satisfactory. According to the original account given by Lucarelli, the patient in whom this parasite occurred was a woman upwards of sixty years of age, and resident at Capodimonte. She had symptoms of calculus, with highly-coloured urine, in which latter there were deposited some small yellowish bodies. They exhibited a definite form, and were apparently organized. Altogether five specimens were collected for examination, when they showed signs of life. Lucarelli also adds:—"After minute investigation, I thought that these creatures were tetrastomes, to which I applied the epithet *renal*, in accordance with their presumed habitation." At the expiration of two months the patient died, and on a *post-mortem* examination being made, no more tetrastomes were found either in the kidney, or in the urinary bladder. The renal organ was slightly enlarged.

8. HEXATHYRIDIUM PINGUICOLA.

H. pinguicola, Treutler; Jördens; Brera; etc.
Hexastoma pinguicola, Cuvier.
Linguatula pinguicola, Lamarck.
Polystoma pinguicola, Zeder; Rudolphi; Bremser; etc.

This species was once found by Treutler in a tumour about the size of a nut, which was connected with the left ovary, and no second instance of its occurrence, either in Germany or elsewhere, has since been recorded. The original figure and description given by Treutler have been copied in various works; and from these records we gather that this trematode attains a length of eight lines, the body being flat, somewhat hourglass-shaped in outline, obtusely rounded in front, and produced behind, so as to form a conspicuous, tail-like appendage. At the anterior and ventral aspect of the head there are six small orbicular pores, serially disposed in a semilunar form, and there is also a sucker-like organ situated in the central line about the root of the tail. A small opening is described as existing at the caudal extremity. Van Beneden and Gervais have supposed that this parasite may, after all, turn out to be the well-known *Pentastoma denticulatum.* This view, however, is quite inadmissible, as one may perceive from a consideration of the size, shape, want of claws, and, more especially, from the presence of a ventral acetabulum in Hexathyridium.

9. HEXATHYRIDIUM VENARUM.

H. venarum, Treutler; Jördens; Rudolphi; etc.
Hexastoma venarum, Cuvier.
Hexacotyle venarum, Blainville.
Linguatula venarum, Lamarck.
Polystoma sanguicola, Delle Chiaje; Frick.
P. venarum, Zeder; Rudolphi; Dujardin; Owen; etc.

This species is better known than the above. Treutler originally obtained two specimens from the blood of the anterior tibial vein of a young man who accidentally ruptured the vessel while bathing, at Leipsic. Rudolphi and others sought to throw doubt on Treutler's observation, and referred these worms to the fresh-water *Planariæ.* At Naples, however, Delle Chiaje subsequently procured specimens from the sputa of two young persons suffering from hæmoptysis; and a fourth instance also appears to have been noticed by Follina, where the worm occured in venous blood. This species attains a length of three lines, is cylindrico-lanceolate in shape, its six suckers being biserially disposed on the under side of the so-called head. Davaine in his "Traité," previously quoted, gives Treutler's original description at full length; but, notwithstanding the nature of the facts recorded, he ventures to suggest that this worm is neither more nor less than the *Distoma lanceolatum*, or a young *Fasciola hepatica*. In this opinion I cannot coincide.

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CHAPTER IV.

CESTODA.

General considerations respecting the origin of human tapeworms—Küchenmeister's great merit in establishing the experimental method of research—The inferences of MM. Pouchet and Verrier successfully opposed by Van Beneden—*Tænia solium*—General and specific characters—Name and history—Anatomy of the strobile and proglottis—Egg and six-hooked embryo—Measle or *Cysticercus cellulosæ.*

We now enter upon the consideration of those species of the great Cestode group of helminths which are liable to infest the human frame; and here it is that we encounter a series of strangely constituted beings, whose development in our bodies is fraught with the most disastrous consequences to health and life. Into the historical part of our subject I do not care to enter at any length, but those who are minded to acquaint themselves on this point can easily do so by procuring a copy of the "Conversations Jahrbücher" for 1863, in which they will find Leuckart's admirable *résumé* of all the principal data bearing on this curious subject.* In justice, however, to those who threw most light upon the helminthological obscurities of the past, I may remark that Dujardin, Eschricht, and Von Siebold were the first to show that the cystic worms (hydatids, acephalocysts, etc.) were only phases in the life-development of the cestoda or tapeworms; but the greatest merit is undoubtedly due to Küchenmeister, who founded the experimental method of demonstrating these relations. As Leuckart remarks, it was Küchenmeister who first "hit upon the idea of administering the measles as provender to other animals, and of studying the changes which took place in the alimentary canal of the quadrupeds thus fed. Such a trial might, it is true, very naturally suggest itself to any one, but this does not lessen the merit due to Küchenmeister, seeing that the result was thoroughly decisive." These experiments gave a new impulse to the study of helminthology, which was now pursued with avidity by several workers co-operating with Küchenmeister, and also by others acting independently, amongst the more prominent of whom one may especially particularize Van Beneden of Louvain and Leuckart of Giessen.

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* "Die neuestern Entdeckungen über menschliche Eingeweidewürmer und deren Bedeutung für die Gesundheitspflege," s. 627.

From the very nature of the experimental method adopted, it was easy to perceive that occasional errors of interpretation would be liable to occur, even in the minds of those who had enjoyed considerable experience in helminthological pursuits conducted after the fashion pursued and systematized by Rudolphi. Von Siebold especially erred in this manner, disputing Küchenmeister's well-ascertained results, and throwing down a gauntlet which in later times has been taken up by others. Thus, not long ago, MM. Pouchet and Verrier gave a general denial to the opinions of experimental parasitologists respecting the development of tapeworms from *Cysticerci.* Those who have read the statement, as presented in the "Comptes Rendus" (for May 5th, 1862, p. 958), or the translation of it given in the July number of the "Annals of Natural History" (3rd series, vol. x. p. 77, *et seq.*), will at once perceive the causes which have led these gentlemen to form conclusions at variance with the experience of at least nine-tenths of the leading helminthologists of the day. As Professor Van Beneden remarks, they err greatly in supposing that any one regards the *Cœnurus* of the sheep as the larva of *Tænia serrata* of the dog, seeing that nearly all Continental experimentalists, following Küchenmeister, have maintained that the *scolex* condition of this last-named tapeworm is unquestionably the *Cysticercus pisiformis* of hares and rabbits. The researches of Leuckart are especially conclusive on this point; and my own experiments at Edinburgh in 1856, together with others since recorded, have left no doubt in my mind as to the correctness of this view. The negative result obtained by MM. Pouchet and Verrier in their last experiment (where they fed two dogs, each with a hundred heads of *Cœnurus cerebralis*) certainly seems contradictory as regards the *Tœnia cœnurus;* whilst, on the other hand, it tends to confirm the correctness of the generally received opinion that *Cœnurus cerebralis* and *Tœnia serrata* have no genetic relation subsisting between them. Into this discussion, however, it is quite unnecessary in this place to enter any further. We may, I think, confidently conclude that the few difficulties which still prevent a uniform adhesion to the current opinions of the day, will, in due time, be satisfactorily explained.

10. TÆNIA SOLIUM.

T. solium, Linneus; Gmelin; Rudolphi; etc.
T. solium (var. *abietina*), Weinland.
T. osculis marginalibus solitarius, Linneus; Bradley.
T. cucurbitina, Pallas; Bloch; Batsch; Schrank.
T. cucurbitina plana pellucida, Goeze.
T. humana armata, Brera.
T. lata, Pruner.
T. degener, Spigel.
T. dentata, Gmelin.
T. fenestrata, Chiaje.
T. vulgaris, Werner.
T. communis, Moquin-Tandon.
T. albopuncta hominis, Treutler.
T. hydatigena anomala, Steinbach.
T. hydatigena suilla, Fabricius.
T. finna, Gmelin.
T. cellulosa, Gmelin; Treutler.
T. e capite bonæ spei, Küchenmeister.
T. capensis, Moquin-Tandon.

General and Specific Characters.—A large species of cestode helminth, in its sexually-mature or strobila condition, varying from ten to twenty, or even, it is said, to thirty feet and upwards in length; breadth at the widest part very nearly one-third of an inch; head about the size of a pin-cap, globular, but produced in front so as to form a short, conical proboscis or rostellum, the latter being armed with a double crown of hooks, from twenty-two to twenty-eight in each circular row; head furnished with four sucking disks, and succeeded by a very narrow neck nearly half an inch in length; the latter being continued into the anterior, front, or sexually immature part of the body, in which traces of segmentation at first appear in the form of fine transverse lines, which gradually becoming more and more widely separated, leave brief interspaces; these parts merging eventually into distinct segments or joints; the earliest formed immature joints are extremely narrow, the proglottis or sexually-mature joint commencing at about the four hundred and fiftieth segment (Leuckart); the total number of joints in a worm ten feet long being upwards of eight hundred (Küchenmeister); mature proglottides twice as long as they are broad, comparatively thin and transparent, furnished with a branched uterus, consisting of a central longitudinal stem, giving off from seven to ten branches on either side; joints in the form of hermaphroditic zooids, having a common reproductive papilla, placed at the border on one side below the central line, but not uniformly either to the right or left in series; male orifice in front or above the vaginal outlet; penis sickle-shaped; eggs rounded; larval or hydatid condition equivalent to the well-known measle or *Cysticercus* (*telæ*) *cellulosæ* of authors.

Name and History.—Not a few persons still suppose that the common tapeworm occurs solitarily in the human body, being naturally led into this error by the Linnean title, which certainly was originally intended to convey a notion which we now know to be erroneous. Frequently, indeed, it occurs singly, but Küchenmeister has several times found two or three together; his colleague, Dr. Pfaff, saw seven; Madame Heller thirty; and Küchenmeister adds, "Dr. Kleefeld of Görlitz once counted forty expelled from one patient." In many cases, where it has been said that one enormous long worm existed, it is more than probable that there were several associated. Thus, in Dr. Coffin's American edition of Brera's "Treatise on Verminous Diseases," which has also been quoted by Weinland, "Van Doeveren relates the history of a peasant who, after taking an emetic, evacuated sixty metres (upwards of sixty-five yards) of Tænia, and who probably would have voided more if he had not broken the worm from an apprehension that he was discharging all his intestines." One can scarcely believe this was a single specimen of *Tænia solium.*

The tapeworm in its strobile condition has been known from the earliest times, though possibly not earlier than the measles, from which the worm originates. Hippocrates, Pliny, and Aristotle described the full-grown worm ; and, in regard to the larvæ, some have gone so far as to express their belief that the prohibition of swine's flesh as food amongst the Jews and other Oriental people, was dictated by sanitary considerations. Weinland suggests that the Mosaic commandment not to eat pork might have originated in an old popular notion " of the fact that tapeworm sometimes comes from this food." Certainly, one must admit the possibility of the truth of Weinland's hypothesis ; for, if one supposes Moses to have been supernaturally informed that (measly) pork would produce tapeworm disease among the people, one naturally asks why veal and beef should not also have been prohibited, seeing that these meats also harbour tapeworm larvæ, nearly as frequently as pork.

Anatomy.—Now that the general organization and mode of development of this species is so well understood, it is a matter of regret that the manifest errors of earlier writers are not more carefully excluded from our ordinary manuals of zoology and comparative anatomy. I allude, for example, to such points as the still asserted presence of a mouth and digestive canal in the *Tœnia*, which cannot be maintained, since repeated demonstrations have clearly proved this view to be erroneous. These falsely so-called alimentary canals constitute the water-vascular system which will be briefly described below. I say " briefly," because the limits and design of this work will not permit me to give excessively minute anatomical details.

The head of *Tœnia solium* is seldom seen in our public anatomical museums, although the evacuation of entire adult tapeworms is not of very rare occurrence. Placed under the microscope, it displays, in addition to the characters already mentioned, a quantity of dark, almost black, pigment granules, which are particularly abundant at the base of the rostellum, and in the neighbourhood of the hook sacs. They exhibit a bright crystalline aspect, and vary somewhat in quality ; this proportion, however, being neither dependent on age nor situation. They are equally present and abundant in the pork-measle, and in the specimens of *Cysticercus cellulosæ* derived from the human subject. The cephalic hooks of this cestode are comparatively large, those of the greater series measuring as much as $\frac{1}{150}''$, whilst the smaller have an extreme length of about $\frac{1}{220}''$. The sharp thorn-like extremities of the hooks of both circles terminate outwardly at a common point of distance from the centre of the rostellum; so that a line carried from point to point, in succession, will indicate the circumferential limit of the double crown, forming, in fact, a simple circle. The roots and stems of the hooks are received into a corresponding double series of socket-like pouches, which are visible even when the hooks themselves may be wanting. They were, I believe, first accurately described by Küchenmeister. The tegumentary covering of the head differs in no important particular from that of the rest of the body, displaying an external thin, smooth, transparent, chitinous epidermis superimposed on a rather thick, fibrous corium. Beneath the

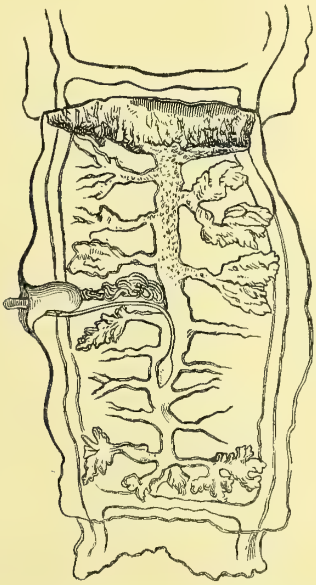


FIG. 46.—Fragment of the strobile of *Tænia solium*, Linneus; showing, more particularly, the reproductive apparatus and water vessels of a single proglottis.—Rokitansky.

latter, there are layers of longitudinal and transverse muscular fibres, pervaded by a great quantity of so-called calcareous corpuscles. These oval bodies, about which more will be said hereafter, also occur in the corium, but not in the cuticular layer. Beneath these structures, in the mature segments, we find a dense layer of parenchyma, which forms a limiting membrane, within which is enclosed the central reproductive mass. This latter consists of an anterior testicular group of elements, and a posterior uterine group. The former, in place of a simple testis, consists of a number of small vesicles or sacs, in which filiform spermatozoa have been detected ; these latter, when ripe, being conducted by a *vas deferens* into a seminal pouch from which a canal passes laterally into the penis; the latter organ, in its retracted condition, being lodged within a flask-shaped sheath or cirrhus-pouch. The female organs are somewhat more complicated. They consist of two masses of vitelligene glands occupying a limited space, a small ovarium, a centrally-placed and largely-developed branched uterus, canals of outlet leading from all these organs, and enlargements of the main passages to form internal seminal reservoirs ; also, a vaginal canal, which is widened at its termination to form a receptaculum for the curved penis. These several parts, as well as their development, have been ably determined and investigated by Leuckart, to whose well-known treatise I must refer those who desire more minute details.

In addition to the above-named structures, the entire series of joints from the head downwards are traversed by a set of vascular canals, which are doubled in the region of the head. These constitute the so-called aquiferous system. It is usually described as consisting of two main channels, one passing down on either side of the worm, and both being connected by transverse vessels, which occur singly at one end of every joint. This statement of their arrangement is substantially correct ; and without entering into minute details, I may here remark, in passing, that they do not form tubes of uniform thickness throughout their course, but present distinct bulbous enlargements at every joint, where the transverse branches are given off. This I have recently ascertained from the careful injection of a perfectly fresh tapeworm. In the neighbourhood of the head the two channels divide to form four distinct vessels, which, according to Küchenmeister, "are united quite at the front of the head by a common transverse branch, as thick as, or thicker than, themselves." Küchenmeister also thought he recognized the existence of cilia within these canals, such as have undoubtedly been shown by Van Beneden, Virchow, Wagener, and others, to occur in allied cestodes.

The eggs of *Tænia solium* in their mature condition present a globular figure, and are easily recognized by their remarkably thick shell, which surrounds the contained six-hooked embryo, leaving a brief interspace between the surface of the latter and the inner layer of the shell. They present an average diameter of $\frac{1}{694}$ of an inch, the shell itself measuring about $\frac{1}{4000}''$ in thickness. As early as the year 1856 I observed that many of the eggs, whilst still within the uterine branches, displayed an outer envelope, very delicate in structure, and totally dissimilar from the egg-shell proper. This has since been more accurately described by Weinland, and especially, also, by Leuckart, who has, moreover, given a minute account

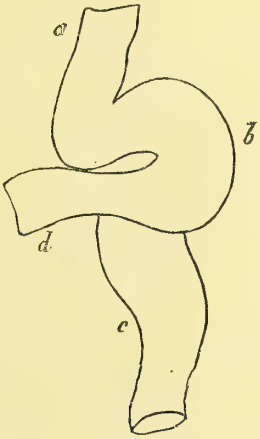
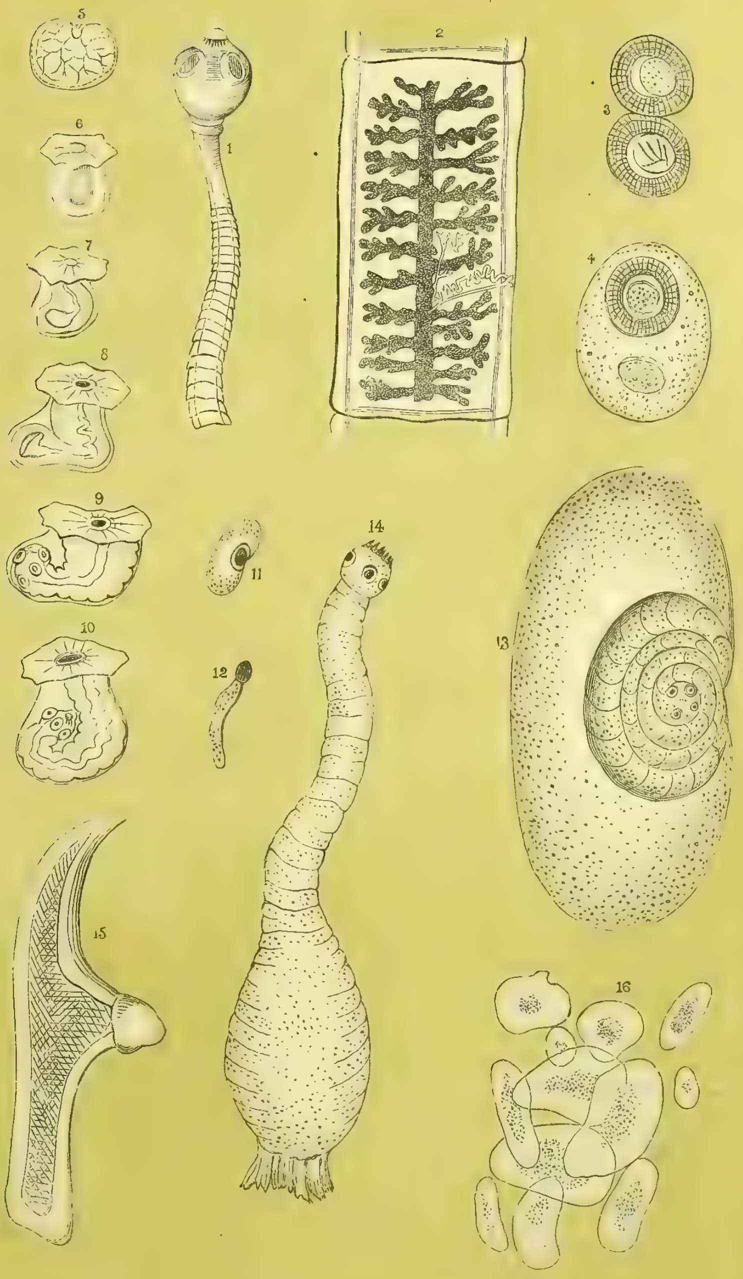


FIG. 47.—Representation of the mode of union of the lateral and transverse vascular trunks in *Tænia solium*; outlined with the aid of a camera (× 40 diam.)—Original.

of the development of the ova and embryos from their earliest commencement. The outer membrane, according to the latter authority, constitutes the primitive yelk-membrane, within which a part of the yelk-contents separate to form the true egg and embryo by a process of daughter-cell formation; the other part of the yelk remains as a granular mass, being concerned, possibly, as an organ for secreting the true chitinous shell (Fig. 4, Plate XII). When the true shell is fully formed and the outer layer is still in existence I have observed this granular mass to be altogether absent. Weinland describes a second delicate or middle membrane within the outer one (in *Hymenolopis*), but this may be only the surface of the coagulated contents, which, in addition to the well-defined granular mass, consists of loose granules floating in a clear albuminous fluid. The true shell displays a series of radiating and circular lines; the former, however, are more conspicuous than the latter, being due, according to Leuckart, to the presence of a series of fine rod-like chitinous elements, which are formed on the external surface of the original true shell membrane. The enclosed embryo presents a simple granular aspect, and is furnished with six boring spines, arranged in three pairs, the whole being invested by an extremely delicate skin-membrane, which is separated from the inner surface of the shell by a clear transparent fluid. The embryo measures $\frac{1}{1250}''$ in diameter.

Leaving the consideration of the *measle* as a disease for subsequent notice, I now proceed to glance at the so-called *scolex* or larval condition of this tapeworm, which in its most complete stage of development constitutes the well-known *Cysticercus* (*telæ*) *cellulosæ* of authors. Its earlier stages of growth have been ably worked out by Leuckart. In this kind of investigation, it is true, he was anticipated by Rainey, but it may be reasonably doubted if the minute corpuscles described by Rainey as representing "the earliest indication of this species of Cysticercus" have anything to do with the measles whatever. It unfortunately happens, also, that the so-called Raineyan sacs with their con-

Plate II.



Tænia solium. Linnæus.

After Blanchard, Leuckart, and Smith.

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tained corpuscles had been previously described by Hessling, who discovered them in the muscular fibres of the heart of the sheep, ox, and roe.* They were regarded by him as granular masses formed by the disintegration or breaking up of the muscular substance, but Leuckart thinks it more probable that they are organized structures comparable to the so-called sacs of Psorospermiæ.

The smallest measles found by Leuckart measured as much as $\frac{1}{25}''$ in length, being obtained from the brain, liver, and intermuscular substance of a pig fed with tapeworm proglottides about thirty days previously. Only those specimens, however, occurring in the liver at this early period, displayed an outer membrane proper to the worm itself, the others being simply invested with capsules formed out of the surrounding connective tissues belonging to the host. Many measle masses in the same host were much larger, presenting an average diameter of $\frac{1}{6}''$. The smallest of the above-mentioned already displayed a smooth, transparent, homogeneous, outer, cuticular membrane, overlying a double, finely-granular corium; the latter being traversed by a branched system of aquiferous vessels. These vessels proceed from a central spot, which marks the position of the so-called head-cone or *receptaculum capitis.* It is, in fact, the first well-marked indication of that flask-shaped capsule within which the head, neck, and body of the Cysticercus is formed, and which Goeze long ago very aptly compared to a lantern (Figs. 5—10, Plate XII). As growth proceeds, a very interesting series of changes takes place within this cavity, by virtue of which these several parts, as well as their own distinctive organs, are continuously brought into view. A central granular mass forms the true foundation of the head, its upper or stalk-like extension forming the future neck and body. Further developmental changes (into the minuter particulars of which the limits of this work forbid me to enter) successively result in the evolution of the internal water-vascular system, the calcareous corpuscles, the marginal transverse foldings of the body, the four suckers, the rostellum, and, in particular, the double coronet of hooks. All these metamorphoses have been minutely investigated and described by Leuckart, who also finds that the complete development of the *Cysticercus cellulosæ* is ordinarily accomplished within the space of ten weeks.

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* Siebold and Kölliker's "Zeitschrift," Bd. v. 1853. See also Leuckart; s. 240.

In its highest grade of formation, the *Cysticercus cellulosæ,* or pork measle, presents the appearance of an elliptical or reniform hydatid, varying in size from that of a pea to that of a small kidney-bean. The measles present an average diameter of $\frac{1}{3}''$, but some exceed this considerably. The vesicle displays a more or less opalescent appearance, the density being much increased at the side where the head and neck is lodged within the so-called *receptaculum,* or Goeze's lantern (Figs. 11—13, Plate XII). If one such measle be dissected or broken up, it will be immediately perceived that the great vesicular portion constitutes the bladder-like caudal extremity of the Cysticercus, whilst the head, neck, and body can be drawn out so as to exhibit a vermiform character. Even before the vesicle is injured, one can readily perceive that these last-named parts lie coiled within the *receptaculum* in a spiral manner. The neck and body display a series of tolerably regular transverse folds, and on microscopic examination, the cephalic hooks, suckers, and calcareous corpuscles are readily brought into view. The hooks, about twenty-four in number, have each a straight shaft, a barb-like anterior root, and a claw-like, sharply-pointed extremity; in other respects they resemble those of the adult tapeworm. In like manner, the calcareous corpuscles, which Smith erroneously designated assimilating cellules, present appearances very little differing from those seen in the full-grown animal. They consist of clearly-defined, circular, oval, elliptic, oblong, or reniform disks, measuring, according to Smith, from $\frac{1}{3000}''$ to $\frac{1}{1500}''$ in diameter. Their more intimate structure and nature will be found fully discussed elsewhere in this work. As regards the general structure of the Cysticercus, I need scarcely add that no trace of digestive or other internal organs can anywhere be distinguished within the body, whilst the caudal vesicle itself is simply distended with a clear, transparent, albuminous fluid.

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CHAPTER V.

TÆNIA SOLIUM.

Development of the common tapeworm—The life phases of *Tænia solium* regarded as parts of the "zoological individual"—Injurious effects upon man—Particular instances—Frequency of Cysticerci in the human brain—Mr. Hulke's case—Precautions suggested—Statistics—Treatment.

Having devoted an entire chapter to the consideration of the general characteristics and structure of the common tapeworm, both in its adult and larval conditions, I proceed, in as brief a manner as possible, to give an epitomised view of the developmental changes and wanderings which are undergone by this species in its passage from the free proglottis condition into the ordinary, sexually mature *Tænia solium*. A part of these life-changes have been indicated already, but their intermutual relations have now to be described and explained under a separate head.

Development.—After the proglottis (which, it must be borne in mind, is furnished with male and female reproductive organs) has undergone impregnation by contact with another proglottis, there results from this the formation of eggs within it, which eggs, whilst still within the body of the parent, develop into embryos, the latter still retaining the egg coverings. At this time the proglottis is about to undergo a passive migration, and having detached itself from the strobila, it is soon expelled from the bowel of the host, thus finding its way into some cesspool, or, it may be, into the open fields. The proglottides move about for a time, but the growth of the multitude of embryos within their interior causes the proglottis sooner or later to burst, and the embryos thus become dispersed; some are thus conveyed down drains and sewers, others are lodged by the roadsides in ditches and waste places, whilst great quantities are scattered far and wide by winds or insects in every conceivable direction. Each embryo is furnished with a special boring apparatus, having at its anterior end three pairs of hooks; the entire group of embryos of any single proglottis is consequently called the "six-hooked brood." After a while, by accident, as it were, a pig coming in the way of these embryos or of the proglottides is liable to swallow them along with matters taken in as food. The embryos, immediately on their being transferred to the digestive canal of the pig, escape the eggshells and bore their way through the living tissues of the animal, and having lodged themselves in the fatty parts of the flesh, they there rest to await their further transformations or destiny. The animal thus infested become measled, its flesh constituting the so-called measly pork. In this situation the embryos drop their hooks or boring apparatus and become transformed into the *Cysticercus cellulosæ.* A portion of this measled meat being eaten by ourselves, either in a raw or imperfectly cooked condition, transfers the Cysticercus to our own alimentary canal, in which locality the Cysticercus attaches itself to the wall of the human intestine, and, having secured a good anchorage, begins to grow at the lower or caudal extremity, producing numerous joints or buds to form the strobila or tapeworm colony.

Thus the cycle of life-development is completed, and we have a simple alternation of generation in which the immediate product of the proglottis (or sexually-mature zooid-individual) is a six-hooked brood; by metamorphosis the latter becomes transformed into the Cysticercus, having a head with four suckers, and a double crown of hooks; and by gemmation the latter gives rise to a whole colony (strobila) of individuals, the greater part of which are destined to become sexually mature zooid-individuals, or proglottides. It will be observed, therefore, that the product of a single ovum is, in the first instance, a single non-sexual embryo; in the second phase, it becomes a non-sexual Cysticercus (these two phases together constituting the protozooid); in the third change it gives off, by budding, numerous gemmules, most of them destined to be sexually-mature individuals (or deuterozooids), in this way resembling their original parents.*

As I have already attempted to show in the case of *Tænia serrata,* the relation and nature of these developmental changes may be further simplified by placing the various life phases in a tabulated form, as follows :—

Zoological Individual . . .	*a.* Egg in all stages.	= protozooid.
	b. Six-hooked embryo = proscolex.	
	c. Resting larva or *Cysticercus* (*telæ*) *cellulosæ* (scolex).	
	d. Immature tapeworm.	
	e. Strobila, or sexually-mature *Tænia solium.*	
	f. Proglottis (cucurbitinus) = free segment = deuterozooid.	

Injurious effects upon Man.—The common tapeworm may be said to act prejudicially against our species in three different ways. It may directly cause disease and death by infesting our bodies, at one time in the adult, and at another time in the larval state; it may also indirectly affect our health and wealth by rendering the flesh of swine innutritious or altogether unfit to be used as food.

When one or more sexually-mature tapeworms have developed themselves within the human intestine, they give rise to a variety of unpleasant symptoms, more or less marked according to the habit or irritability of the patient. According to Davaine (p. 103 of his "Traité") the principal features are "vertigo, noises in the ears, impairment of sight, itching of the nose and anus, salivation, dyspepsia and loss of appetite, colic, pains over the epigastrium and in different parts of the abdomen, palpitation, syncope, the sensation of weight in the abdomen, pains and lassitude in the limbs, and emaciation." In addition to these, many other anomalous symptoms may present themselves, or, as Davaine remarks, periodical fits of faintness, with one or more of the above accompaniments, may recur with considerable regularity. Of course, in all cases where a suspicion exists as to the cause of these symptoms, a true solution can only be arrived at by ocular proof of the passage of proglottides or cucurbitini. In most cases, restlessness and anxiety are conspicuous features, and it has also been observed that the symptoms acquire a greater intensity in female patients. The increase or loss of appetite on the one hand, and the absence or presence of diarrhœa on the other, are criteria of very little value, as their occurrence or non-existence is altogether uncertain. In severe cases, the sympathetic phenomena become very strongly marked, manifesting themselves in the form of hysterical fits, chorea, epilepsy, and epileptiform seizures, in which the convulsions may become extremely alarming.

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* Part of the above is taken from my article, "Alternation of Generations," in the supplement to the sixth edition of "Maunder's Natural History."

Amongst some of the more interesting and remarkable cases recorded in our English journals, I may instance that of Mr. Hutchings, where a complete cure followed the evacuation of the worm which had produced convulsions. Mr. Tuffnell records a case where irritability of the bladder and stricture of the urethra were entirely dependent on tapeworm, as proved by the subsequent recovery. At a meeting of the Pathological Society, in 1853, Dr. Winslow mentioned his experience of three or four cases of mania arising from tapeworm; whilst on the same occasion Drs. Ryan and Davey each recorded a similar instance. A case had also been previously published by Mr. W. Wood. At a meeting of the London Medical Society, held on the 10th of April, 1837, Dr. Theophilus Thomson (during an interesting discussion on this subject) stated the facts of a case where the presence of tapeworm had given rise to a tumultuous action of the heart; this symptom entirely disappearing after evacuation of the worm. Our journals likewise (anonymously) record a considerable number of cases from foreign sources. Thus, in the "London Medical Gazette" for 1840, there is the case of a lady, aged thirty-seven, who had convulsions attended with complete loss of consciousness, the separate fits lasting an hour at a time. The passage of the worms effected a complete cure. In the same journal for 1838, there is also the case of a younger lady (aged twenty-seven) suffering from epilepsy, in whom a complete cure had been similarly brought about; here, however, in addition to a single specimen of the *Tænia solium*, there were two lumbrici present. This journal also gives Ettmuller's case, where eighteen tapeworms were the cause of hysteria; and likewise the case published by Steinbeck, where the symptoms presented an altogether peculiar character. More precise references to the above, and other instances, will be found in the "Bibliography" of this work, under the author's names.

Distressing as some of the above-described phenomena are, the injurious effects they produce are as nothing compared with the calamities which follow the deposition and growth of the tapeworm larvæ within our bodies, at least, when these so-called Cysticerci take up their abode in our more important vital organs. Fortunately, this latter contingency is of comparatively rare occurrence, and yet it is probable that at least one hundred cases have come to light, where the *Cysticercus cellulosæ* has caused death by its development within the human brain. Griesinger alone has collected between fifty and sixty such cases, two of which came under his own observation. From a minute analysis of these cases he has attempted to establish a series of diagnostic signs by which the presence of Cysticercus in the brain may be recognized. Even should he have succeeded in this respect, one is at a loss to comprehend how any curative result could accrue from the formation of a correct diagnosis. It is a step, however, in the right direction; and we gather from his accurate observations (for reference see "Bibliography") that in some instances the symptoms may be obscure or altogether wanting. In a second set of cases, epilepsy exists without mental disturbance. In a third set epilepsy is accompanied with true maniacal symptoms, or there may be simple imbecility. In a fourth set, mental disturbance may occur without the epilepsy; whilst in another group of cases there is ordinarily neither epilepsy nor mental perturbation, but in these, however, cerebral symptoms of irritation or torpor ultimately supervene shortly before death. When Griesinger adds, moreover, that "the epilepsy from Cysticercus is in all respects like cerebral epilepsy, and the psychical disturbances in general have nothing characteristic about them," he seems almost to make the admission that the diagnosis of Cysticercus in the human brain is next to impossible. Even if our suspicions were aroused as to the presence of tapeworm larvæ in the brain, it would, of course, be utterly impossible to say whether the larvæ in question were referable to *Cysticercus cellulosæ*, or whether they were the ordinary hydatid-acephalocysts of *Tænia echinococcus*. Moreover, in the cases on record, where the larvæ have been removed *post-mortem*, we have not always been satisfactorily informed as to their true character. In addition, also, to the above-mentioned symptoms, Griesinger and others have noted that in some cases the phenomena were not unfrequently attended with peculiar symptoms, "such as squinting, alteration in the pupils, avoidance of light, headache, coma, anomalous sensations in the limbs," etc.

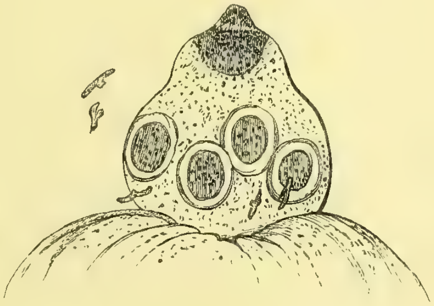

Fig. 48.—Head of *Cysticercus cellulosæ* from the human brain (× 50 diam.). Mr. Hulke's case.—Original.

Cysticerci may develop themselves in almost any situation in the human body, but they occur most frequently in the subcutaneous, areolar, and intermuscular connective tissue; next most commonly in the brain and eye, and lastly, in the substance of the heart and other viscera of the trunk. Several interesting cases have appeared in our own journals. Thus Mr. Toynbee records a case of an hydatid (which I take to be the *Cysticercus cellulosæ*) situated in the middle cerebral fossa beneath the *dura mater*, but in this instance death ensued from other causes. Mr. Ottley gives the case of a woman aged forty, where an undoubted Cysticercus in the brain gave rise to distressing fits, convulsions, and death. Then, again, there is Dr. Burton's workhouse patient, only twenty years of age, who was found dead in bed, and who at the time of admission merely complained of pain in the head. After death, four hydatids (*Cysticerci*) were found in the *tuber ancillare* at the summit of the spinal marrow. M. Bouvier's similar case is also reported in our periodicals. Of instances, also, where Cysticerci occupied the cavity of the eye, we have one or two cases by Mackenzie of Glasgow, one by Mr. Rose of Swaffham, and others by Windsor, Logan, and Estlin. Amongst the more peculiar cases, I may mention that described by Dr. Greenhalgh in the "Lancet" (1848), where the Cysticercus was lodged within the substance of the lip. Five similar cases are likewise recorded by Heller of Stuttgard. Then there is Dupuytren's case of a Cysticercus ensconced within the great peroneus muscle; and also Fournier's, where several of these scolices were said to have been found in a boil. Lastly, I may observe that the well-known example of the so-called *Trachelocampylus*, discovered by Frèdault in the human brain, is neither more nor less than the common *Cysticercus cellulosæ*.

It is worthy of remark, as Griesinger has also observed, that in cases where the Cysticerci have taken up their temporary residence in the brain, they are usually found, *post-mortem*, in the grey cortical or peripheral substance of the cerebrum. The record of an (hitherto incompletely described) instance of this kind, for the particulars of which I am indebted to my colleague, Mr. Hulke, will faithfully illustrate the pathological appearances ordinarily exhibited in such cases.* The "host" or bearer of this parasite was a patient at King's College Hospital, and he suffered from epileptic fits, one of which caused his death in the month of January, 1855. A *sectio cadaveris* revealed the presence of numerous small cysticercal hydatids in the brain, near the surface. The conditions presented by one or two of the Cysticerci, with and without their investing capsules, are represented in the accompanying woodcut (fig. 49) from original drawings executed by Mr. Hulke. The subscribed references will suffice to explain the more minute details. As there were several specimens of the Cysticercus present I have since had

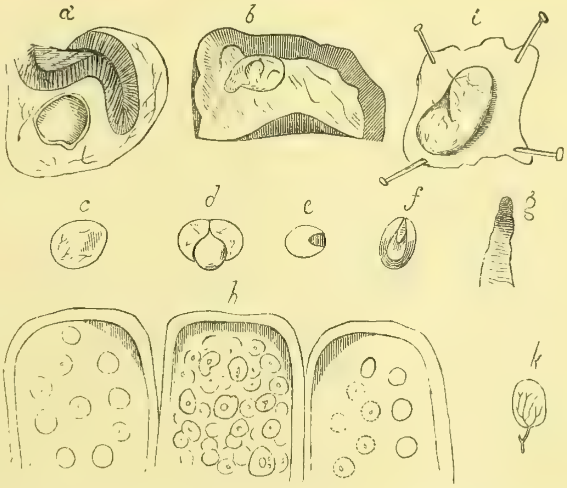

FIG. 49.—*a*, Portion of the brain with a cyst *in sitû*, showing the capsule surrounding it; *b*, similar section, with a second capsule; *c*, cyst removed from its capsule, to exhibit its vascular character; *d*, the same torn open, and displaying the more delicate hydacyst within, which partially protrudes itself; *e*, the little bladder-like *Cysticercus* entirely separated; a dark spot marking the position of Goeze's lantern (*receptaculum capitis*); *f*, the same partly unfolded; *g*, the unrolled head, neck, and body of the *Cysticercus*, separated from the caudal vesicle in which it was lodged, and flattened under a thin portion of glass; it exhibits an opacity about the head and numerous conspicuous transverse lines; *h*, portion of the same, showing that the transverse lines are due to tolerably regular foldings of the integument; it also exhibits the transparent epidermis in profile, a number of delicate lines running in the long axis of the segments, and a series of nucleated vesicles (calcareous corpuscles); *i*, dissection of the capsule of another specimen, exposing the vascular cyst *in sitû*; *k*, isolated cyst, with a vessel ramifying upon its external surface.—Hulke.

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* This case is briefly illustrated in my paper on "Parasite Larvæ" in the "Intellectual Observer" for March, 1863, No. xiv., vol. iii., p. 90; Dr. Burton's case being also referred to in the same memoir.

an opportunity of dissecting out one or two which had been purposely left untouched; and a careful examination of these enables me to speak confidently as to their true character. Contrary to the recorded experience of one or two observers, I found the pigmentary (melanine) particles quite as abundant in these specimens as they are known to be in Cysticerci derived from the pig. In the neighbourhood of the rostellum and crown of hooks they formed a dark, black patch, as is shown in the woodcut copied from a drawing which I made with the aid of a camera (fig. 48). The four suckers, the calcareous corpuscles, and several of the detached hooks are there displayed, and likewise the upper part of the caudal vesicle which still encircles the neck.

Precautions.—As we have found that the species under consideration is injurious to man in two of its life-phases, it necessarily happens that our precautionary measures should partake of a double character. The now very generally diffused notion that it is dangerous to eat raw or underdone pork is certainly based on correct reasoning; and the promulgation of this important truth is unquestionably due to the original discoveries of Küchenmeister. But it is not alone sufficient that we avoid underdone *meat*, in the ordinary acceptation of the term, seeing that measly pork is often employed in the making of sausages, which may also be imperfectly cooked. If, therefore, any one has a particular liking for this kind of food, I would say to such a person: "It is by no means necessary that you should give up eating sausages, but observe when you cut them across whether the cooking process is complete. If you notice a central, pink, raw-like, fleshy look about the centre which is always clearly defined in an underdone sausage, and yet partake of this food, you are not secure from infection; there *may* be a measle within, and therefore you would do well to insist upon the recooking of the dainty." Under ordinary circumstances, we are safe for the following reasons:—No respectable butcher will knowingly supply us with pork or sausages which are measled. Even in underdone meats, in whatever way prepared, it is usually only a small part of the meal which is unaffected by cooking. The temperature of boiling water is quite sufficient to destroy the vitality of the measles. In ordinary salted pork, the Cysticerci are destroyed by the salt acting chemically and mechanically upon their tissues and juices. In most cases the like effect is produced on pork which is smoked in the preparation of hams. Of course, in all these instances there may be imperfection in the choice and preparation of these foods, without any dishonesty on the part of the butcher, salesman, or cook. A few Cysticerci may also exist without their being seen, and the flesh of the animal may even appear particularly inviting. In thoroughly diseased swine, however, the case is very different; and here there can be no excuse for the sale of such diseased meat, though one admits there ought to be some method of compensation to the butcher. In badly measled swine the flesh on section presents a disgusting, spawn-like appearance, due to the confluency of the numerous little bladder-like vesicles or Cysticerci. Here, it is obvious, there is danger even in the cutting up of the flesh. The knife employed by the butcher—it is sometimes even incautiously placed in his own mouth—is indiscriminately used to cut up any other meats at hand, and not unfrequently the vesicles are transferred from meat to meat, and from meat to mouth. This is one reason why so many butchers suffer from tapeworm. Cooks also, in like manner, will cut bread, cheese, and other foods with the same knives which they have just previously been employing to slice or chop up pork which may have contained a few, or even many Cysticerci, and thus, again, the mode of infection is accounted for. Many other similar circumstances by which the larvæ may be transferred to the human stomach will also naturally suggest themselves; but in reference to this part of the subject, I will here only further remark that it is a delusion to suppose that other meats, such as veal and beef, are free from parasite larvæ. These foods, as will be presently shown, also harbour Cysticerci, which give rise to the development of tapeworms scarcely less injurious than the *Tænia solium.*

There are other dangers, however, in store for us, even supposing we avoid the tapeworm-chances above mentioned. These have reference to the harbouring of the six-hooked embryos which, when they have gained access to our own bodies, will, as I have previously shown, develop into measles. Our flesh, like pork, thus becomes measled, although certainly not to the spawn-like extent so often seen in the lower animals. A single measle alone, unfortunately, is sufficient to prove fatal, and this ugly contingency, moreover, is one which we can never be absolutely certain of avoiding. We become the "host" or bearer of the measle by swallowing the fully-developed eggs of the *Tœnia solium.* This we may do directly by handling fresh tapeworms, whose almost invisible eggs, by concealment under our nails or in our clothing, may subsequently drop upon or may be brushed into our food, and when swallowed, develop within us accordingly. Even a thorough washing of the hands will not render us absolutely secure from invasion—I mean those of us, especially, who devote ourselves to the experimental investigation of helminthological science. In like manner, our neighbours who complacently devour choice salads made from the stores of the market-gardener, also run a certain amount of risk, not only as regards this entozoon, but, indeed, as respects several others. The appropriate vegetables may be manured with night-soil containing myriads of tapeworm eggs, or they may be watered with fluid filth, and other abomination into which these eggs have been cast by variously possible ways. In such cases, one or more tapeworm ova may be transferred to our digestive organs, unless the vegetables are carefully cleaned before they appear on the table. In the same way, one perceives how fallen fruits, all sorts of edible plants, as well as pond, canal, and even river water procured from the neighbourhood of human habitations, are liable to harbour the embryos capable of gaining an entrance to our bodies. It thus becomes evident also how one individual suffering from tapeworm may infect a whole neighbourhood, rendering the swine measly; these animals, in their turn, spreading the disease far and wide. Such a person may even prove dangerous to the life of his friends and neighbours, and especially also to members of the same household. A case of this kind has come to my knowledge, and it may be explained as follows:—One or more free proglottides or joints with their eggs had escaped from the bowel, either at night voluntarily on their part, or during the day passively, in some such way, at all events, as secured the liberation of scores, possibly thousands, of ova. One of these escaped eggs had somehow or other come in contact with human food, or possibly had been blown into the mouth, or even, perhaps, had been carried on the legs of some fly into the milk or sugar on the table; in some such manner, at least, the egg found its way to the stomach, and from thence it got into the circulation, ultimately making its passage to the brain, where its presence gave rise to convulsions and death. I offer this as a probable explanation in the case of a young woman whose sister suffered from tapeworm, but I need not say that out of the sixty or seventy deaths recorded from the ascertained presence of this "worm in the brain" it is more than likely that a similar train of reasoning would afford a true solution of the so-called mystery as to how these entozoa become our brain-guests. Very frequently we entertain the same larvæ as guests within our muscles and beneath the skin; but, after all, the *Cysticerci* or larvæ of our *Tænia solium* are rare visitants to the human territory when compared with the larvæ of another kind of tapeworm which destroys hundreds of the human species annually. Of this and several other visitants, non-celestial, in the sense of their being neither few nor far between, I shall speak more fully under the head of *Tænia echinococcus;* but before concluding this part of my subject I may allude to what appears to me to be the most remarkable case of development of Cysticerci within the human body on record. It is that recently recorded by Delore in the "Gazette Médical de Paris." In a man, aged seventy-seven, who died from pulmonary catarrh, old age, and fractured *cervix femoris*, there were two thousand Cysticerci found *post mortem.* Of these, one hundred and eleven occurred in connection with the nervous centres, eighty-four being in the cerebrum, twenty-two in the membranes of the brain, four in the cerebellum, and one within the substance of the medulla oblongata.

Statistics.—The relative abundance of tapeworms in the human body is in consonance with the habits of the people, but at present our statistical data are rather meagre. "Herr Wauruch of Vienna states that of 3864 persons treated in the space of twenty years at an hospital of that city, 206 were affected with Tænia. Of these latter, 71 were males, and 135 females. The oldest individual affected was a man of fifty-four, the youngest being a girl of three years and a half of age. Most were persons between fifteen and forty years of age. Persons most concerned with animal provisions were those observed to be chiefly attacked; for, of the 206 patients, 1 was a man, and 52 were women cooks, several were butchers, and eleven were eaters of large quantities of meat. Among predisposing causes, the principal were (considered to be) a habitation in a damp neighbourhood, and the use of injured aliments, as bad bread, flour, butter, potatoes, etc., but particularly *bad mutton*, pork, and water." These facts are particularly interesting, and their value is not a little enhanced by the circumstance that they were culled at a time long antecedent to our recent helminthological discoveries. (For the original quotation from "Oesterr. Med. Jahrb.;" see "Lancet" for May 13, 1843, p. 229.) Some curious and more recent statistical data will be found further on in this work, under the head of *Tænia mediocanellata.*

Treatment.—On this score I propose to say very little, as our standard medical works, and especially also our periodicals, literally teem with cases in which the employment of particular remedies have been more or less strongly advocated. Discrepancies, it is true, occasionally cast a doubt as to the relative value of certain drugs; but, in the main, there is a general agreement, as well as a prevalent adoption of well known medicinal preparations. In the case of the adult worm, the happiest cures are readily effected by the expulsion of the "guest," but as regards the larvæ the case is very different.

When the latter have reached the brain, it is manifest that they are beyond the reach either of the physician or surgeon; they may, however, be readily removed by the skill of the latter when, as not unfrequently happens, they occur in the subcutaneous cellular tissue, in the muscles, in and beneath the tongue, and in various other comparatively superficial parts of the body. I have, indeed, already dwelt on this subject, and therefore it now only remains for me to indicate the principal medicinal agents, somewhat after the fashion of their generally received order of merit. First of all, then, stands the rhizome or root of the male shield fern (*Lastrea filix mas*), which may be administered either in the form of decoction or simple powder, or, best of all, in the condition of the etherial extract. In the hands of Christison, Fleming, Jenner, Goodfellow, Greenhow, Vinen, and many other experienced physicians, this remedy has proved unfailing. Secondly, Kousso, or the dried and powdered flowers of *Brayera anthelmintica*, is an extremely valuable remedy. Drs. Barclay, Weinland, and several others, have given this plant a bad name, but their unsuccessful employment of it does not accord with the experience of Dr. R. Dane and scores of other medical practitioners in this country. Thirdly, there is Panna, or the root of a South African fern (*Aspidium athamanticum*), which has, however, no special advantage over the common European fern. Lastly, in regard to the host of other remedies which have been recommended, I need only mention a few, such as pomegranate-bark (*Punica granatum*), oil of turpentine (*Oleum terebinthinæ*), tin (*Stannum precipitatum*), seeds of *Myrzina Africana*, seeds of the common pumpkin (*Cucurbita pepo*), kamala from the fruit of *Rotleria tinctoria*, santonine (*Artemisia santonica*), oxide of silver (*Argentum oxidum*). Each of these drugs have one or more warm supporters. Dr. E. J. Waring, in his able brochure (quoted in the bibliography of this work), speaks very highly of pomegranate root-bark, and also of kamala (*Kámeelá* or *Kámalá*), and he gives an account of several other more or less valuable Indian anthelmintics, one of which is the *Gisekia pharmaceoides* of

Linneus. This is a small plant growing everywhere in waste places. According to one authority, it is superior to either kousso or kamala. The *Butea frondosa* of De Candolle is another. The seeds of this plant form a popular remedy with the Hindoo and Mussulman doctors. It is also given to expel ascarides. *Garcinia pictoria*, or the gamboge of Mysore, is another. This remedy was introduced into European practice by Dr. Hugh Cleghorn, but according to Waring, "it holds a very secondary place, and should not be employed if the pomegranate or kamala is procurable." Its action is violent, necessitating the employment of small and often-repeated doses.

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CHAPTER VI.

TÆNIA MEDIOCANELLATA.

General and specific characters of *Tænia mediocanellata*—Feeding experiments of Leuckart and Mosler—Acute cestode tuberculosis—Statistics—Kaschin's account of the prevalence of tapeworm amongst the Cossacks of the Baikal—*Tænia acanthotrias, T. flavopuncta,* and *T. nana*—Probable identity of *Tænia elliptica* with *T. cucumerina*—Structure of the so-called *Cysticercus tenuicollis,* or larva of *Tænia marginata.*

THE appropriation of the two preceding chapters to the consideration of the structure, development, and economy of the common tapeworm enables me to describe the remaining human cestodes with less particularity of detail as regards their structure, but with more fulness in respect of their injurious effects upon our bodies. This will be found necessary, at least, when considering the larval states of the *Tænia mediocanellata* and *T. echinococcus*, whilst some of the other species will be found to present features of interest peculiar to themselves.

11. TÆNIA MEDIOCANELLATA.

T. mediocanellata, Küchenmeister; Eschricht; Leuckart; etc.
T. solium, Bremser (and others, in part).
T. dentata, Nicolai.
T. cucurbitina grandis saginata, Goeze.
T. inermis, Moquin-Tandon.
T. tropica, Moquin-Tandon.
Tæniarhynchus mediocanellata, Weinland.

General and Specific Characters.—A cestode helminth, considerably exceeding the previously described species, both as regards length, breadth, and the thickness of its individual segments; the head also somewhat larger, abruptly truncated at the crown, destitute of a rostellum, and consequently, also, of an hook-apparatus; furnished with conspicuously large sucking-disks, which are usually surrounded by a great quantity of dark pigment granules, imparting to the head a blackish appearance; the sexually-mature joints characterized by the possession of a more complicated uterine organ than even that of *Tænia solium*, presenting nearly double the number of lateral branches, which do not, moreover, branch out so dendritically as those of the so-called common tapeworm, being also more closely packed and running outwardly in an almost parallel manner; as in *T. solium*, the first sexually-mature proglottis occurs somewhere about the 450th joint, but whereas, in the former species, only some 200 subsequent segments share this perfect character, in *T. mediocanellata*, on the other hand, there may be present as many as 360 or even 400 mature joints (Leuckart); the reproductive papilla occurs considerably below the centre of the lateral margin; the joints are singularly liable to form monstrosities, these abnormalities sometimes affecting the reproductive organs, which become doubled or even trebled.

The establishment of this species as distinct from *T. solium* is unquestionably due to Küchenmeister; but it is not a little curious to observe how accurately this determination was foreshadowed by that shrewd naturalist and theologian, J. A. E. Goeze, who, in his "Versuch einer Naturgeschichte der Eingeweidewürmer thierischer Körper," clearly indicates two forms of the common tapeworm, remarking (s. 278) :—"Die erste ist die bekannte grosse, mit langen dicken und gemästeten Gliedern, die ich *Tænia cucurbitina, grandis, saginata*, nennen will." The same author (s. 245), it will be remembered, also pointed out the resemblance subsisting between the tapeworm of the cat (*T. crassicollis*) and the vesicles ("Krystallblasen") and their contained "erbsförmige Blasen" (*Cysticercus fasciolaris*) of the mouse. In this way it was that the celebrated pastor of St. Blasius, in Quedlinburg, almost contemporaneously with the equally-distinguished zoologist Pallas, thus early arrived at the conclusion that the hydatid-measles were a kind of tapeworm.

It is scarcely necessary for me to indicate more minutely the distinctive peculiarities which distinguish this species from the common *Tænia solium*, for although they are, indubitably, very well marked, I do not think them sufficient to warrant the formation of a new genus for the reception of this species. Thinking otherwise, Dr. D. F. Weinland has suggested the generic title of *Tænia-rhynchus*. M. Moquin-Tandon was also unwilling that the title originally given by Küchenmeister should be retained, because, as he said, it was "badly compounded, one of its roots not being a Latin word." The name, however, is sufficiently correct, and has the advantage, moreover, of referring to an interesting, almost specific, character in connection with the water-vascular system. The worthy discoverer describes it as consisting of a main transverse channel "running through the free space between the four sucking disks; from this a branch runs to and around the suckers until the four well-known longitudinal vessels are developed from them in the neck." These, as in *T. solium*, are continued downwards on either side near the margins of the segments throughout the entire series, but it would seem that they are not supplied with the well-known transverse (segmental) branches, which characterize the joints of the common tapeworm.

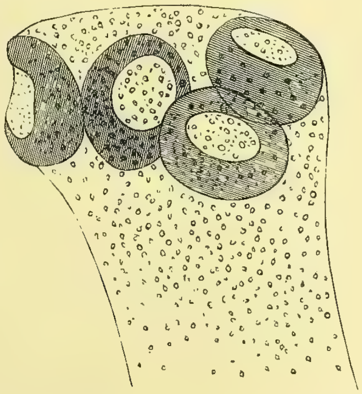

FIG. 50.—Head of *Tænia mediocanellata;* from a specimen prepared by Mr. Frederick Turner. Drawn with the aid of a camera (× 40 diam.)—Original.

As regards the mode of development of this hookless flat-headed tapeworm, the recent experimental researches of Leuckart incontestably prove that the "measles," or cysticerci which produce them, are to be found in the muscles and internal organs of cattle; and in his valuable work ("Die menschlichen Parasiten," p. 406, *et seq.*), he gives a condensed account of his experiments with the fresh eggs of *Tænia mediocanellata.* He fed two calves with the proglottides of this worm. The first animal experimented on died from a violent attack of the measle-disease, which resembles a kind of leprosy. This malady has since been, not altogether inappropriately, characterized as "acute cestode tuberculosis." On dissecting this calf, the muscles were found filled with measles, or imperfectly developed scolices. On the second occasion a smaller number of proglottides (in all about fifty) were administered; but the febrile symptoms again appeared with such virulence that Leuckart thought this animal would die also. Fortunately, after the lapse of a fortnight from their commencement, some abatement of the disease took place; and this gradually continued until the animal was perfectly restored to health. Eight and forty days subsequent to the feeding (*i.e.*, reckoning from the earliest days of alimentation, for the feedings were continued at intervals up to the eighteenth day) Professor Leuckart extirpated the left cleido-mastoid muscle, and whilst performing the operation had the satisfaction of seeing the cysticercus-vesicles lodged within the muscles. They were larger and more opalescent than those of the so-called *Cysticercus cellulosæ*, but, nevertheless, permitted the recognition of the young worms through their semi-transparent capsules. The heads of the contained cysticerci exhibited all the distinctive peculiarities presented by the head of the adult strobila (*Tænia mediocanellata*); and thus, taking the results of this experiment in connection with previously ascertained facts, we are supplied with the most unequivocal evidence that man becomes infested by this second form of tapeworm by eating imperfectly-cooked veal and beef. In all probability, other animals are not liable to harbour the cysticercus of the *Tænia mediocanellata*, for Leuckart also tried to infect a sheep (to which he administered about sixty proglottides), but on examining the flesh after the lapse of eight weeks, he failed to detect the presence of a single cysticercus vesicle.

Leuckart has also personally informed me that he has, in conjunction with Professor Mosler, repeated this kind of experiment with precisely similar results, and since our interview I find he has placed the particulars of the experiment on record in the appendix to the third part of the first volume of his invaluable treatise.* In this third case a healthy calf, three months old, was fed first with one hundred proglottides, and three days afterwards with fifty more. At the eighth and eleventh days respectively, subsequent to the worm-feeding, several morbid symptoms made their appearance. "The animal lost appetite, be-

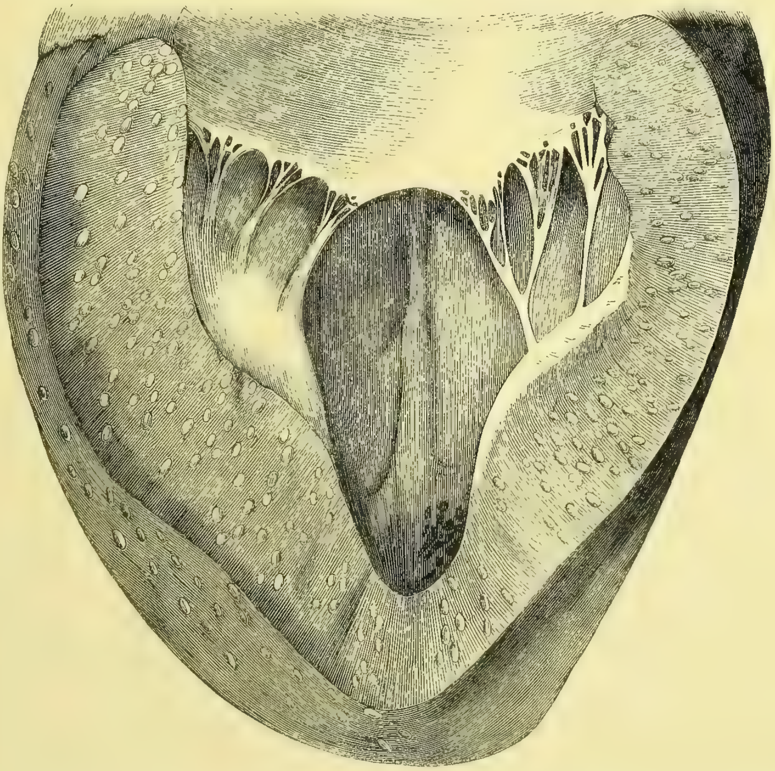

FIG. 51.—Section of the heart of a calf which died from acute cestode tuberculosis, produced by the administration of proglottides of *Tænia mediocanellata*. (Natural size.)—Mosler.

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* "Die menschlichen Parasiten," Erst. Bd. s. 747.—This experiment has since been more fully detailed by Mosler himself, in his brochure, entitled "Helminthologische Studien und Beobachtungen." Berlin, 1864.

came feverish, declined, and died (as happened in the first experiment) three weeks after the commencement of the feeding. The heart was found œdematously infiltrated, and occupied by many hundred measle-cysts (Fig. 51); these pathological changes, in the opinion of Mosler, having caused the animal's death." Taken altogether, therefore, Leuckart's three separate experiments incontestably prove the true source of our *Tænia mediocanellata*, and they demonstrate the correctness of the persuasions previously entertained by Küchenmeister in the first instance, and by Huber and Schmidt subsequently, respecting the bearers of the larvæ. Another attempt by Leuckart to produce the measles of this tapeworm in the pig gave, as before, only a negative result.

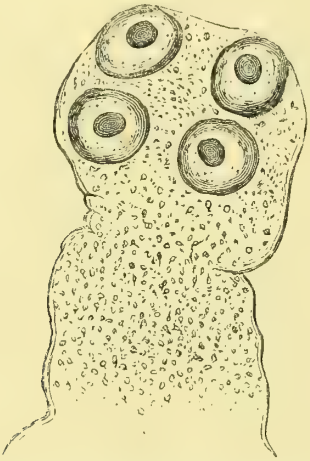

Fig. 52.—Head of the larva (scolex, or *Cysticercus*) of the *Tænia mediocanellata;* from a specimen prepared by Leuckart. Drawn with the aid of a camera (× 30 diam.)—Original.

Through the kindness of this distinguished zoologist, I am in possession of several measles removed from one of these calves. The characteristic hookless head, represented above, is that of a cysticercus about twelve weeks old; that is to say, it was artificially reared within the body of a calf, having been introduced in the egg (or six-hooked embryonic) condition three months before the animal's death. This larva, as in the adult worm, presents a truncated, flattened head, four large rounded suckers, a total absence of the rostellum, but great abundance of the so-called calcareous corpuscles.

Statistics.—As the means of distinguishing the two foregoing tapeworm-species become more readily and widely diffused, so may we hope to arrive at a more accurate estimate as to the relative abundance of the last-described worm as compared with the *Tænia solium.* Hitherto both have been classed together, and it has been assumed that the *Tænia mediocanellata* is a comparatively rare species in this country. I for one, however, do not doubt that their respective prevalence will ultimately be found to be pretty well on a par, though, probably, the *T. solium* will maintain a slight ascendancy, partly in consequence of the cheapness of pork as compared with veal and beef, and partly because the lower classes are slow to be instructed in any matters which suggest or involve a change in their habits of life, and especially any alteration as regards their food. Drs. Barclay, W. T. Gairdner, and many others in this country, have published cases where their patients were disgustingly addicted to the habit of eating raw flesh; but, of all the striking facts which have come to light on this score, none will bear comparison with those recorded by Kaschin.* This professional observer, speaking of the Burätes, or Cossacks of the Baikal region, says, "In Irkutsk, the Burätes stationed there as Cossacks, and who, in part, have been away from their homes for many years, are, almost all of them, infested by tapeworms; some individuals harbouring as many as fifteen specimens at a time. In one hundred and thirty *post-mortem* examinations only two bodies were found entirely free from these parasites, and among five hundred other persons, treated in hospital, the existence of these entozoa was demonstrated in all. Certainly, the presence of these parasites cannot cause surprise when the habits of their bearers are duly considered. The Burätes are herdsmen, and feed almost exclusively upon flesh, especially that of calves, sheep, camels, and horses; they neither clean the meat of these animals properly, nor cook it completely, and, moreover, they eat from tables which immediately before have served for the purpose of cutting up the flesh. The tables are just as little familiarized with the application of water, as are the dishes and the people themselves; in other words, they are never cleaned. Fat, liver, and kidneys are eaten quite raw, and diseased animals are as much relished as half-rotten carcases. Moreover, these Burätes are so voracious that any two of them can demolish a one-year old lamb at a single meal!" Kaschin supposes these tapeworms to be referable to *T. solium*, but in this, as Leuckart points out, he is evidently mistaken: for not only are the ruminants the principal source of their food, but they comparatively rarely partake of pork. The Burätes not unfrequently also suffer from hydatid disease.

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* First communicated by Kaschin in the Russian language ("Petersburger Med. Zeitung," 1861, vol. i., p. 366), and subsequently communicated (in German) to Professor Leuckart by Herr C. Paulson of Petersburg. See Leuckart's "Die Menschl. Parasiten," erst Bd. s. 748.

Leuckart also mentions that Dr. Krabbe of Copenhagen finds the *T. mediocanellata* quite as frequent as the *T. solium* in Denmark. Out of thirteen tapeworms in Krabbe's possession, no less than seven belonged to the former species. This agrees with my own experience; for, on looking over our museum specimens at the Middlesex Hospital, I was surprised to find at least half the worms referable to *T. mediocanellata*.* Leuckart also, to whom I

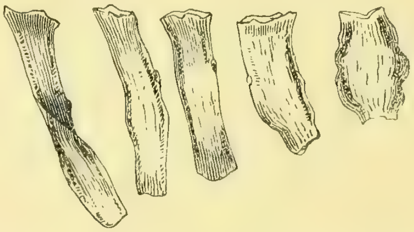

Fig. 53—Free proglottides of *Tænia mediocanellata* in various states of contraction.—Leuckart.

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* Out of five tapeworms since submitted to my examination, four are of this species. One very fine example, from Dr. Greenhow, has the head perfect, and consists of about 1000 joints, or, without reckoning the first inch, where it is difficult to count them, of 946 easily recognized segments.—T. S. C., June 20, 1864.

showed a selected series, cleared up my doubts as to one or two fragments. Moreover, Dr. Aitken finds this species more abundant amongst the soldiers stationed at Fort Pitt, than the so-called common tapeworm. Finally, it has become conspicuously evident that the hookless tapeworm is as abundant in this country as the *Tænia solium.* One may even go so far as to state that, admitting occasional exceptions, the hooked worm infests the poor, and the hookless worm the rich. This circumstance accords with the fact that the lower classes subsist chiefly upon pork, whilst the wealthier prefer mutton, veal, and roast beef.

12. TÆNIA ACANTHOTRIAS.

T. (*Cysticercus*) *acanthotrias,* Weinland; Leuckart; etc.
Acanthotrias, Weinland.

The specific distinctness of this new tapeworm is founded on the examination of several cysticerci, "preserved in the Collection of the Medical Improvement Society, Boston, and in the Anatomical Museum, Cambridge, U. S." From twelve to fifteen of these cysts were found by Dr. Jeffries Wyman (1845) in the muscles of a woman about fifty years of age—a dissecting-room subject at Richmond, Virginia. Dr. Weinland, of Frankfort, during his stay in America (1858), on carefully examining one of these cysticerci, made the very curious, and, in some respects, unique discovery that its rostellum was furnished with three rows of hooks, fourteen in each, the hooks themselves presenting the usual characters. Dr. Weinland proposes to elevate this species as the type of a new genus (*Acanthotrias*); but unless the (yet to be discovered) strobila displays other characters differing from those of ordinary tapeworms, it is, perhaps, better to retain it among the *Tæniæ.*

13. TÆNIA FLAVOPUNCTA.

T. flavopuncta, Weinland; Moquin-Tandon; Leuckart.
? *T. flavomaculata,* Molin.
Hymenolopis flavopuncta, Weinland.

The existence of this worm as a distinct species is also due to the shrewd investigations of Dr. Weinland, made during his visit to America. Unfortunately, no perfect specimen has been seen; but, from portions of at least six examples of the strobila, Dr. Weinland has clearly established its claim to be recognized as a good species. The proglottides are short; and "there is a yellowish spot, clearly visible to the naked eye, situated about the middle of each joint, which reminds us very much of the colour and situation of the genital organs, as known in *Bothriocephalus*." The reproductive orifices occur all along one side of the worm; and the eggs are unusually large. Only one instance of the occurrence of this species is yet recorded; and on this occasion they were obtained by Dr. Ezra Palmer, in considerable numbers, from an infant nineteen months old. They were expelled without medicine, their presence not having been even suspected.*

14. TÆNIA NANA.

T. nana, Siebold and Bilharz; Küchenmeister; Leuckart; etc.

T. ægyptiaca, Bilharz.

Diplacanthus nanus, Weinland.

Küchenmeister, in his enthusiasm, was led to indulge the hope that this minute tapeworm would turn out to be his imaginary *Tænia echinococcus altricipariens;* and I find that Van Beneden has fallen into the error of describing the *Tænia echinococcus* of Siebold under the title of *T. nana*. This is unfortunate. Weinland, on the other hand, has suggested the formation of a new genus for the reception of this worm; but the so-called "bifid" character of the hooks (as described by Bilharz) is a misnomer, the "doubled" appearance being simply due to the close approximation of the claw and the anterior root-process (Leuckart). The hooks are essentially the same as those of other *Tæniæ*, only they are very minute and slightly peculiar in form. The full grown strobila attains a length of 8 or 10 lines, and carries from 150 to 170 joints. The cysticercal condition is at present unknown; but Leuckart thinks it may be found in some kind of insect.

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* See D. F. Weinland's "Essay on the Tapeworms of Man," p. 49; also his "Beschreibung zweier neuer Tænioiden aus dem Menschen," 1861, p. 8, tab. iv.

15. TÆNIA ELLIPTICA.

T. elliptica, Batsch; Rudolphi; Creplin; etc.
T. canina, Pallas; (also probably Linneus; Eschricht; etc.)
T. canina felis, Werner.
T. cucumerina, Bloch; Rudolphi; Creplin; etc.
? *T. cateniformis*, Goeze; Gmelin; Rudolphi.
T. cateniformis felis, Gmelin.
T. cuniceps, Rudolphi.
? *T. osculis marginalibus oppositis*, Linneus.
? *Alyselminthus ellipticus*, Zeder.
A. cuniceps, Zeder.
? *Halysis elliptica*, Zeder.
Dipylidium elliptica, Leuckart.

This delicate cestode, when full grown, is usually about six or eight inches in length, and is easily recognized by its double set of reproductive organs, the outlets of which occur in the centre of papillæ placed opposite each other, or, in other words, one on either side at the centre of the margin of every proglottis. The head is furnished with a conical rostellum, armed with several rows of minute hooks.

From the statement long ago made by Eschricht, that he had received a *Tænia canina*, passed by a negro slave at St. Thomas, Antilles, and more especially from the clear evidences recently adduced by Leuckart ("Die mensch. Parasiten," s. 402), there cannot be a shadow of doubt that either the *Tænia elliptica* of the cat or the *T. cucumerina* of the dog may be reckoned amongst the cestodes liable to infest man. Those who, with Leuckart, regard the cat's tapeworm as a distinct species from the *Tænia cucumerina* of the dog will probably (on reading the evidence put forth by Leuckart) come to the conclusion that both these worms infest the

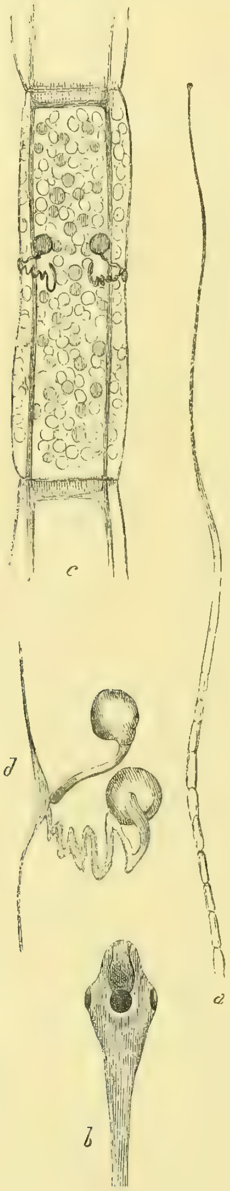


FIG. 54.—*Tænia elliptica*; *a*, upper part of the strobile (nat. size); *b*, head (× 25 diam.); *c*, sexually mature proglottis (enlarged); *d*, male reproductive organs (× 60 diam.)—Original.

human body. I have examined these reputedly distinct forms, and I find that there are differences of size and outline affecting the joints, but I cannot yet follow Leuckart and pronounce them to be of sufficient value for specific separation. Until recently, I was in the position of Dujardin, who had not seen this parasite's head ; I have now, however, procured and examined a great number of perfect specimens, and am still unable to pronounce the two forms to be distinct species. Goeze's drawings of *T. cateniformis* only represent a single row of little hooks ; and it is well known that the same processes in *T. cucumerina* are very liable to fall off, so much so that it has been described as a hookless tapeworm. Van Beneden regards the two presumedly distinct forms as identical, and, although his representations of the cephalic hooks of *T. canina* correspond very closely with those of the *T. cucumerina*, both of Dujardin and Leuckart, he speaks of three or four rows of hooks, whilst Dujardin says there are three, and Leuckart simply describes a succession ("mit einer mehrfachen Reihe"), though his excellent figure (fig. 118, p. 400, of his work) represents four; he also describes three or four rows as occurring in *T. elliptica.* It is therefore evident that variations occur in the same form as regards the head; and it is more than probable that differences of habitat may be sufficient to account for the variations of size and numerical development of the joints, which Leuckart regards as distinguishing marks between the elliptic tapeworm of the cat and the cucumerine cestode of the dog. Be this as it may, one or other of these forms has been noticed in the human subject several times ; but as regards the source of their larvæ we are yet in uncertainty. When engaged (1856) in rearing *Tænia serrata* from *Cysticercus pisiformis,* I thought I had also hit upon the scolices of *T. cucumerina ;* but Leuckart has since extended my experiment by feeding rabbits with the proglottides of *T. cucumerina,* without producing any measles. Van Beneden has also tried to produce the young of *Tænia elliptica* in the rat, but without result. Weinland thinks the cysticercus of *T. cucumerina* will be found in flies, and that dogs obtain the larvæ by their interesting habit of snapping at dipterous insects. This, at least, is ingenious.

In connection with these views of Weinland and Leuckart, I may here mention that I have fed a number of cockroaches (*Blatta orientalis*) with the eggs of *Tænia cucumerina* of the dog, but I have not succeeded in rearing any cysticerci in their bodies. Not discouraged by negative results (which often advance our science as much as positive ones), I yet purpose to feed some of these insects with the eggs of *T. elliptica* from the cat; and if I should succeed in thus giving the cockroaches the "measles," I shall then have less hesitation in pronouncing Leuckart's opinion, as to the distinctness of these two tapeworm-forms, correct.

16. TÆNIA MARGINATA.

T. marginata, Batsch, Rudolphi, Dujardin.
T. cucurbitina, Pallas; Bloch.
T. lupina, Schrank.
T. cateniformis lupi, Goeze.
T. ex cysticerco tenuicolli, Küchenmeister.
T. tenuicollis, Günther; Moquin-Tandon.
T. hydatigena, Pallas; Bloch.
T. hydatula, Linneus.
T. globosa, Rudolphi; Gmelin.
T. simiæ, Gmelin.
T. ferrarum, Gmelin.
T. caprina, Gmelin.
T. ovilla, Gmelin.
T. vervicina, Gmelin.
T. bovina, Gmelin.
T. apri, Gmelin.
Halysis marginata, Zeder.

This species infests man only in the immature or cysticercal condition, the full-grown tapeworm (strobila) being found in the dog and wolf. It has often been confounded with the *Tænia serrata*, from which, however, it differs in the comparatively bulky size and peculiar form of its hooks; it is also a much larger worm, the proglottides nearly equalling those of *T. solium.* It does not seem possible for the strobila to take up its abode in the human body, because Dr. Möller's attempts to infest himself with it (by swallowing several specimens of *Cysticercus tenuicollis*) were unsuccessful. In the larval condition this worm has an unusually wide distribution; for, in addition to its asserted occasional presence in man, it has likewise been found in various monkeys, in cattle and sheep, in many other ruminants, in horses, in swine, and even in squirrels. The experiments of Küchenmeister, Leuckart, Luschka, and Röll have fully established the fact that these various animals, and ourselves, become infested with the so-called *Cysticercus tenuicollis* by accidentally swallowing the eggs of *T. marginata,* or *Tœnia ex cysticerco tenuicolli* (Küchenmeister), which is the same thing. The cysticerci occasionally attain an enormous size, as was the case with those I obtained from the Wart and Red River Hogs which died at the Zoological Society's Gardens in 1859 and 1860, and which I at first supposed to be referable to two hitherto unknown tapeworms ("Proceedings of Zoological Society," March 12, 1861). Leuckart, however, to whom I forwarded one of the specimens, has corrected me in this matter. In one, the caudal vesicle was pyriform and about five inches in length; in another it had the size and form of a cricket-ball.

The principal evidence, which we have, as to the occurrence of the larval condition (*Cysticercus tenuicollis*) of this tapeworm within the human body, rests on two cases recorded in Schleissner's "Nosography of Iceland." One of these cases, however, has been proved by Küchenmeister, and also by Eschricht's friend and pupil, Dr. Krabbe, to be that of an echinococcus; so that, after all, there only remains the solitary case, observed by Schleissner himself, in which this parasite can, with any degree of certainty, be regarded as a true *Cysticercus tenuicollis.*

As the definitive solution of several interesting questions depends upon a correct appreciation of the relative structure, chemical constitution, and disposition of the calcareous corpuscles as observed in the various groups of Entozoa in which they are known to abound, I have investigated the characters of these singular bodies with very considerable care. In the *Cysticercus ex Potamochœro penicillato* (as I originally termed it) I did not detect any of these bodies within the walls of the caudal vesicle; but they were extraordinarily abundant within the head and neck, and, by their highly refracting properties, imparted to the tissues (when viewed by transmitted light) a dark pigment-like hue, almost obliterating the limiting membranes of the inverted head. They

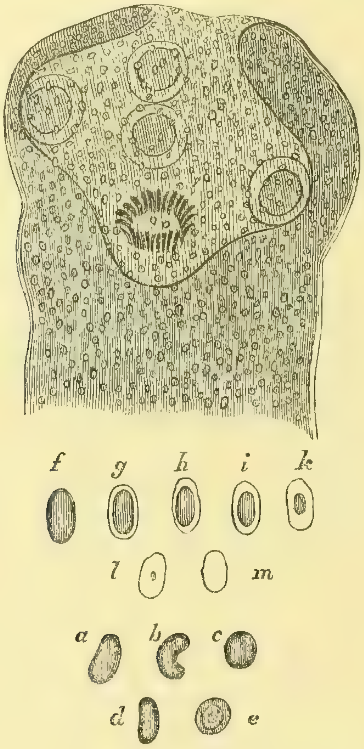


FIG. 55.—Enlarged view of the head of *Cysticercus tenuicollis* from the Red River Hog (*Potamochœrus penicillatus*) ; *a, b, c, d, e,* isolated calcareous corpuscles of various shape, and *f, g, h, i, k, l, m,* one of the corpuscles gradually dissolving under the action of *liquor potassæ* (× 220 diam.)—Original.

were even more numerous than has been indicated in the accompanying drawing (fig. 55), but their relative disposition and size are accurately represented. Their form is commonly that of spherical or oval, flattened disks (fig. 55, *f*, *c*, *e*); but not unfrequently they are elongated, occasionally thicker at one end than the other (*a*, *d*), and sometimes reniform (*b*). All are bordered by an opaque margin; and they often display evidences of concentric lamination, the rings resembling nuclei and nucleoli (*e*). In respect of size, they do not, for the most part, at least, vary materially; they have an average length of $\frac{1}{1400}''$ to $\frac{1}{1000}''$, and a breadth of from $\frac{1}{2000}$ to $\frac{1}{1400}$ of an inch. On the addition of diluted sulphuric acid, a rapid effervescence took place, accompanied with the total destruction of the corpuscles; whereas the alkaline reagent liquor potassæ caused only a gradual dissolution of the enveloping membrane, leaving merely a perfectly transparent and thin calcareous plate, unpossessed of any appreciable light-refracting properties. The change, just mentioned, proceeded uniformly from without inwards; the corpuscle marked *f* (fig. 55) presenting, at intervals, appearances precisely like those indicated at *g*, *h*, *i*, *k*, *l*, and *m*. The last is the isolated calcareous plate, whose circumferential border has lost that entire smooth outline which the unaltered corpuscle invariably exhibits.

From recent investigations, and more especially from those of Claparède, I think we may inferentially draw the following conclusions:—

These bodies cannot be regarded in the light of pathological products, as Moulinie and others suppose; and it is still more obvious that Tschudi, Gulliver, Goeze, and Zeder were wrong in describing them as eggs. Eschricht, and the late Professor William Smith of Cork, clearly erred in attributing to them a special nutritive function, when the former spoke of them as "elementary granules" having a function analogous to that of the blood and lymph-corpuscles, and the latter described them as "assimilating cellules." Professor Van Beneden is probably also as incorrect in viewing them as cutaneous glands "secreting a mucus destined to lubricate the surface of the body."

To offer a true explanation of their character and purpose is still, however, a matter of great difficulty; for there seems to be no doubt that in some instances, especially in mature cestodes and in certain trematodes, the presence of carbonate of lime is contra-indicated. The circumstance also of Claparède's having discovered these bodies to be included within dilatations or cœcal pouches connected with the excretory system of *Holostomata*, considered in association with the fact that I have myself found them lodged in peculiar oviform sacs in *Tricuspidaria* (*Triænophorus*), would likewise seem to forbid our acceptance of Von Siebold's notion, that the bodies in question are comparable with the "spicules and calcareous networks" strengthening the integument of Echinoderms. Nevertheless, this generally-received notion of a cutaneous skeleton seems more readily acceptable than the philosophical opinion entertained by Huxley, who regards these so-called calcareous corpuscles as homologically identical with the thread-cells of the hydroid polyps.

CHAPTER VII.

TÆNIA ECHINOCOCCUS.

General and specific characters of the *Tænia echinococcus*—Grounds for disputing Küchenmeister's notion that there are two distinct forms of Echinococcus—Structure and development of the adult worm—Hydatids—Exogenous, endogenous, and multilocular varieties—Growth and structure—Formation of the scolices within brood capsules—Opinions of Owen, Wilson, Busk, Huxley, Naumyn, and Leuckart, severally contrasted.

I HAVE purposely curtailed my account of the comparatively unimportant cestodes described in the last chapter, in order that I may dwell with more particularity on the only remaining tapeworm, namely, the *Tænia echinococcus.* This species, in its larval condition, is probably more injurious to the human race than all the other species of entozoa put together; or, to say the least, it is more frequently the immediate cause of death than any other internal parasite. Its importance may be realized from the fact that M. Davaine, in his well-known "Traité des Entozoaires," extending over eight hundred pages of letterpress, devotes nearly three hundred pages to the consideration of cases illustrative of the so-called hydatid formations. These are the larvæ of this cestode.

17. TÆNIA ECHINOCOCCUS.

T. echinococcus, Von Siebold; Leuckart.
T. echinococcus scolicipariens, Küchenmeister.
T. granulosa, Gmelin; Prochaska.
T. viceralis socialis granulosa, Goeze.
T. nana, Van Beneden.

General and Specific Characters.—A remarkably small cestode helminth, seldom exceeding the fourth of an inch in length and developing only four segments including that of the head; cephalic extremity capped by a pointed rostellum, armed with a double crown of comparatively large-rooted hooks, from thirty to forty in number; the four suckers prominent, and succeeded by an elongation of the cephalic segment forming the neck; final segment, when sexually mature, equalling in length the three anterior ones; reproductive papilla at the margin of the proglottis below the central line; proscolex or embryo forming large proliferous vesicles, in which the scolices (= echinococcus heads) are developed by gemmation internally.

This little tapeworm (in its strobila condition) infests only the dog and wolf, but its well-known larvæ, constituting the so-called hydatids of medical writers, are of very frequent occurrence in the human body. These hydatigenous formations, according to the particular features they may happen to present, or in accordance with the fancy of the writer, are sometimes called acephalocysts, echinococci, echinococcus vesicles, pill-box hydatids, etc.

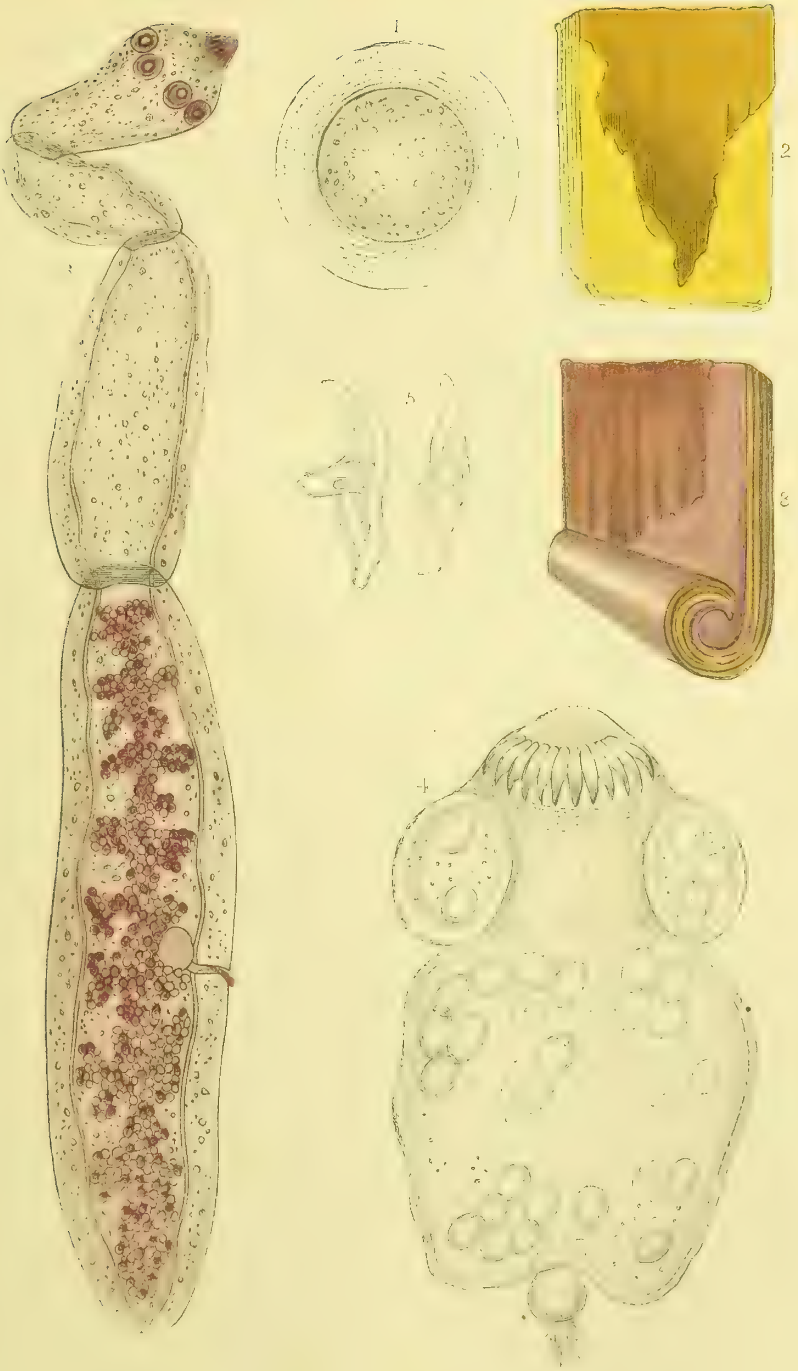
Following Küchenmeister, it has been supposed by Weinland and others that there are two distinct forms of *Echinococcus* severally referable to different tapeworm-species, one of which is, on all hands, admitted to be Von Siebold's *Tænia echinococcus*, the other an unknown *Tænia*, also supposed to infest dogs. That *Echinococci* vary much, both in regard to the number of cephalic hooks they display at certain intervals of growth, and also in respect of the mode of evolution of the scolices, few will deny; but, according to Leuckart, we are not therefore warranted in accepting Küchenmeister's view as to the specific distinctness of certain forms. Like Weinland, I had been, in the first instance, led away by Küchenmeister's authority, although I had enjoyed abundant opportunity of investigating these singularly interesting larvæ. The grounds on which Leuckart disputes Küchenmeister's view are, to my mind, perfectly satisfactory; for he shows conclusively that the proportional number of hooks fluctuates in both forms, that is, in Küchenmeister's *Echinococcus scolicipariens* and *altricipariens* alike, whilst the alleged differences in the size and character of the hooks themselves have reference to their degree of development ("Die menschlichen Parasiten," s. 328, *et seq.*). If this view be generally accepted, it cannot fail to suggest important hints as to the best mode of checking that formidable endemic known as the Echinococcus disease of Iceland, the best account of which we owe to the researches of Eschricht. Before, however, I enter systematically upon the subject of hydatids it is necessary for me to say a few more words respecting the structure and development of the adult tapeworm which gives rise to these formations.

In many particulars this species differs from the other cestodes we have considered, but the more noticeable of these variations have reference to the form and disposition of the reproductive organs. If the lowermost segment be examined, it will be seen to exhibit the usual central uterine rosette, and an equally conspicuous intromittent organ which is often protruded. The relation of these parts to the other sexual elements is seldom fairly seen, but their connection has been tolerably well made out by Von Siebold and Leuckart, from whose writings, aided by specimens, one may gather a tolerably correct notion of their disposition. The essential male organ consists of numerous testicular sacs, communicating (by the intervention of numerous seminiferous ducts) with a common *vas deferens.* These sacs are sparsely scattered over the lower part of the segment, and present the appearance of small pyriform bodies. The *vas deferens* is very much twisted upon itself before it enters the cirrhus-pouch; the latter being very largely developed. According to Leuckart, one not unfrequently sees the extremity of the penis bent round and inserted into the commencement of the vagina, constituting, in point of fact, the act of coitus. If his views are correct, the proglottides are thus self-impregnating, but I must confess that I am sceptical on this point. Thus, supposing Leuckart is right, one naturally asks such questions as the following:—Why need there be so large a development of the penis and its pouch? Why is the surface of the former as well as that of the lining membrane of the vagina furnished with such a formidable array of spines? Why is the intromittent organ so constantly seen protruded at the margin of the joint? And why need there be any external outlet, sphincter, or papilla? It is extremely difficult to believe in this notion of self-impregnation, notwithstanding Leuckart's clear descriptions and the figure wherein he represents (s. 339 *l. c.*) the "Penis in Begattung." In the hermaphroditic flukes, self-impregnation has likewise been supposed to be the sexual method, but, since my discovery of two distomes in the very act of coitus, I have ceased to believe in the generally-received notion of a self-impregnation. It may be, however, that I am wrong, and I cannot but respect Leuckart's authority.

The female reproductive apparatus consists of the ordinary elements, but their relative degree of development and arrangement is somewhat peculiar. According to Leuckart, the vaginal passage is enlarged near the middle of its course, after which (proceeding inwards) it enlarges to form a pouch, which I take to be the internal seminal vesicle. Near this point one would naturally look for a communication with the dendriform uterus, but, if Leuckart's description can be relied on, it is very different. Immediately after forming this pouch (which contains a ball of spermatozoa rolled together) the vaginal canal—if such it may be called—subdivides, one branch forming the main passage going to or coming from the yelk-forming glands, the other going to or coming from the ovary and the great uterine rosette. The glands in question form two small lobulated organs, one on either side of the lower part of the proglottis, the single ovarium, of about equal size, being placed in the central line a little below these organs. As the connections of this second or inferior division of the so-called vaginal canal are so peculiar, I shall transcribe Leuckart's own description, which runs as follows:—"The second canal divides into two passages, of which one is continued on to the sac-like single ovarium, and is consequently the true oviduct, whilst the other probably communicates with the uterus. The latter passage seems to constitute a wide cavity from the commencement, for one recognizes it rather late after the yelk-glands have emptied their contents into it, and have disappeared. Shortly afterwards the ovarium likewise vanishes, and then the development of the embryo commences in the interior of the uterus. The opaque body which is present in the other tapeworms, forming a central point of the entire female apparatus, and which, in all probability, serves as the place of egg-formation, is here altogether wanting." If this description be correct, we have here a singular reversal of the relative position of the parts as ordinarily seen in cestodes, and a remarkably early disappearance of the organs primarily concerned in the development of the eggs.

Development.—On this head a great deal has been written, but the limits of this work will forbid my giving more than a general outline of the subject, avoiding, in some measure, the controversial points. In the main, no doubt, the developmental features of this species can be made to harmonize with those already set forth as regards the other cestodes, but the variations of detail and complexities arising out of unusually peculiar appearances render it no easy task to trace out all the phenomena as they successively come to light. Without further comment, I proceed to remark that the eggs, supposed to be about five thousand in number in a full grown joint, develop in their interior the usual six-hooked embryo. These embryos are introduced into our bodies (and into those of other parasite-bearers) by our partaking of water, or food into which the eggs have been carried by accident or otherwise. After arriving within the apparently selected host, the behaviour of the embryos accords, at least, in the first instance, with that of other tapeworm proscolices. With an especial liking for the liver, they bore their way into this organ, or are carried along the circulating current into other organs. In these situations they sooner or later become transformed into simple vesicular, bladder-like bodies, commonly called acephalocysts or hydatids.

Thus far, it will be seen, the larval development strictly conforms to that ordinarily observed in cestoda, but from this period a series of changes occur which are not only unique in themselves, but, on many accounts, are deserving of the most serious attention of the physiologist and naturalist. Instead of displaying the ordinary cysticercal form, characterized by the head, neck, and body, etc., the vesicle retains throughout its life-changes a more or less globular or oval figure. In the earliest stages at which it has been observed, the juvenile hydatid is perfectly spherical, and is invariably surrounded by a capsule of condensed connective tissue formed from the organs of the host. As shown in the accompanying illustration (Plate XIII., Fig. 1) the vesicle after removal from its capsular covering, consists simply of a thick laminated membrane, forming the so-called cuticle or cuticular layer, and an inner granular mass, which subsequently becomes enveloped by a delicate transparent granular membrane. At the fourth week, the echinococcus capsule measures about the $\frac{1}{25}$ of an inch in length, its contained hydatid being little more than the half of this diameter. Its subsequent growth is by no means rapid, seeing that at the eighth week the hydatid has attained only the $\frac{1}{15}''$ or thereabouts. At this period, Leuckart shows that the internal or granular mass develops a number of nucleated cells on the inner surface of the so-called cuticle. These cells, which are at first rounded or oval, become angular or elongated in various directions, and, even, distinctly stellate; in this way a new membrane is formed, constituting the so-called inner membrane or granular layer. The intermediate stages between this condition and that of the mature or fully-formed echinococcus hydatid have not, so far as I am aware, been satisfactorily made out. This partly arises from the circumstance that the echinococcus heads are only developed from the internal membrane after the expiration of a considerable lapse of time. Leuckart, in his fourth experiment, hoped to have found the heads (scolices) developed within the vesicles, but although nineteen weeks had elapsed since the time of feeding, and the hydatids were about as large as nuts, no trace of heads could anywhere be found. It becomes evident, therefore, that many months must elapse before echinococci are developed within our bodies after we



[illegible] Von Siebold.

(P[illegible] from [illegible].)

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have swallowed the proper tapeworm eggs and their contained embryos.

In regard to the subsequent changes which, in due time, bring about the development of the sexually mature *Tœnia echinococcus*, I need not say much, nor need I dwell on the ancient opinions entertained by Rudolphi, Röll, and others, that these little tapeworms were the young of the *Tœnia cucumerina*, *T. serrata*, and other well-known cestode species. It must suffice me to indicate the present position of our knowledge as regards points of importance only; and here, therefore, I may at once remark, that Von Siebold was the first to breed these tiny tapeworms by the experimental method. Many other helminthologists have since verified his results, amongst whom, of course, Küchenmeister, Haubner, and Leuckart have played a most conspicuous part. I have myself several times fed dogs with echinococci derived from sheep, and also from the human subject; but, for some unexplained reason or other, this series of experiments has only yielded negative results. I mentioned this to Leuckart, who expressed surprise, and could only account for my non-success by the supposition that the food subsequently supplied to the animals had been unsuitable, or had acted anthelmintically. According to Küchenmeister, a period of eight or nine weeks is required for the development of the administered echinococcus-heads into sexually mature tapeworms, but Von Siebold and Leuckart found them full grown in seven weeks. Their especial haunt is the duodenum and upper part of the small intestines, in the mucus of which they lie embedded with their heads attached to the villous surface of the gut. The milk-white appearance of the joints betrays their presence, but they may be easily overlooked, especially if they happen to be only incompletely developed.

Hydatids.—Although I have already briefly described the principal developmental phases of the Echinococcus tapeworm, the importance of this subject, in a medical point of view, demands a more particular account of hydatid formations. At the outset of this chapter, I hinted that all the known Echinococcus forms were reducible to one specific type; or, in other words, were referable to a single species of tapeworm, and not to two separate *Tæniæ*, as Küchenmeister had led us to suppose. Leuckart was the first to demonstrate the correctness of this view; but the opinion that the Echinococci were all of one kind was long previously entertained by several observers, and among others, by a no less eminent authority than Livois, who, in his "Recherches sur les Echinocoques, chez l'Homme et chez les Animaux," states that he could recognize no distinction of species. As the literature of this subject is both extensive and curious, I subjoin a list of the various synonyms under which hydatids have been described, together with a few of the names of the authors by whom these technical terms were severally employed:—

Echinococcus hominis, Rudolphi; Bremser; Chiaje; etc.
E. veterinorum, Rudolphi; Bremser; Gurlt; etc.
E. scolicipariens, Küchenmeister.
E. altricipariens, Küchenmeister.
E. polymorphus, Diesing, Leidy.
E. granulosus, Rudolphi.
E. simiæ, Rudolphi.
E. hydatidosus, Leuckart.
E. giraffæ, Gervais.
Polycephalus hominis, Goeze; Jördens.
P. humanus, Zeder.
P. granulosus, Zeder; Cloquet.
P. echinococcus, Zeder; Tschudi.
Acephalocystis, Laennec; Diesing; Dujardin; Nitzsch; etc.
A. ovoidea, Laennec; Cloquet; Deslongchamps; Chiaje.
A. granulosa, Laennec; Cloquet; etc.
A. surculigera, Laennec; etc.
A. endogena, John Hunter; Owen.
A. exogena, Kuhl.
A. macaci, Cobbold.

A. ovis tragelaphi, Cobbold.
Vesicaria granulosa, Schrank.
Hydatigena granulosa, Batsch.
Hydatis, Lüdersen; Rudolphi; Olfers; Bremser; etc.
H. erratica, Blumenbach.

The employment of these various names indicates that their several authors, until quite recently, recognized in the hydatid an independent and specifically distinct organism; and it seems not a little humiliating for us now to have to declare our persuasion that the forms here named are one and all of them larval conditions of the little *Tænia echinococcus* of the dog and wolf. But so it is; and whilst the mature worm has thus a very limited territory for its place of residence, its peculiar larvæ, on the other hand, are found dwelling in a great variety of animals. Amongst the bearers are men, monkeys, sheep, oxen, deer, camels, the giraffe, and other ruminants; also the horse, ass, zebra, several feline animals, and, perhaps, the squirrel. Von Siebold also described an example of Echinococcus from the lung of a turkey.

Hydatids present very variable appearances according to their situation and mode of formation; thus, we have three principal kinds which may be severally described as exogenous, endogenous, and multilocular. The first kind are sparingly found in man, but are extremely common in the lower animals, whilst the second is most frequently developed in the human subject, the third kind being, I believe, only found in man. The two first forms sometimes coexist in the same bearer, though I have not myself witnessed any instance of this. Instances of the kind are recorded by Haen, Wunderlich, and Davaine.* In the lower animals hydatids generally occur in the form of single globular or lobulated cysts, varying in size from a walnut to that of the egg of a goose. Usually there are several cysts occupying the same organ, or, not unfrequently, several organs in the same bearer. As Livois has remarked, they are particularly liable to occupy the liver and lungs of the same animal; these viscera being sometimes riddled, as it were, with separate cysts. They do not usually protrude much beyond the common surface of the infested organ, but they lie, for the most part, imbedded within its parenchymatous substance. Selecting any ordinary fresh example of the exogenous or of the simple kind, and laying the tumour open with a scalpel, we notice in the first instance an escape of a clear transparent amber-coloured fluid, which previously caused the distention of the hydatid sac. If the tumour is large, this escape will probably be followed by a falling in, as it were, of the gelatiniform hydatid membrane, in which case the external adventitious investment or true fibrous cyst will be laid bare at its inner surface. If the hydatid be next withdrawn from the cyst, it will be seen to display a peculiar and characteristically tremulous motion, at the same time coiling upon itself wherever there is a free cut margin (Fig. 3, Plate XIII). Further examination of portions of the hydatid will show that we

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* References to these cases are given by Leuckart in a footnote (*l. c.* s. 365).

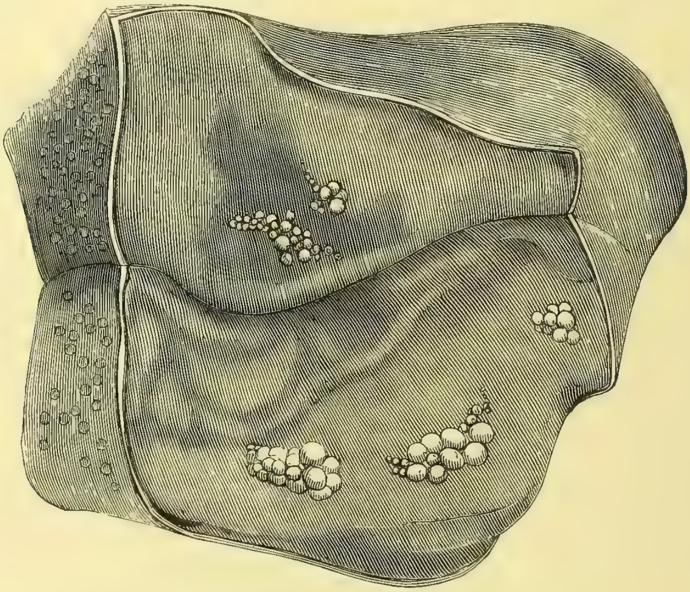

FIG. 56.—Portion of the liver of a pig, with an hydatid cyst laid open to display several groups of proliferating daughter vesicles. Natural size.—Busk.

have two distinct membranes; an outer, thick, laminated, homogeneous elastic layer (the *ectocyst* of Huxley), and an internal, thin, soft, granulated, comparatively inelastic layer—the *endocyst* of the same author. As these terms are extremely convenient and simple, I shall frequently employ them. Histologically, the ectocyst is structureless, consisting of a substance closely allied to chitine; for this and other reasons it is not unfrequently called the cuticular layer; the endocyst, on the contrary, is the essential vital part of the animal, representing, according to my ideas of morphology, a huge compound caudal vesicle. In an example from the zebra, Huxley found that it was "not more than $\frac{1}{2000}$ of an inch in thickness, being composed of very delicate cells of $\frac{1}{2000}''$ to $\frac{1}{5000}''$ in diameter, without obvious nuclei; but often containing clear, strongly refracting corpuscles, generally a single one only in a cell." Huxley adds: "These corpuscles appear to be solid, but by the action of dilute acetic acid, the interior generally clears up very rapidly, and a hollow vesicle is left of the same size as the original corpuscle. No gas is developed during this process, and sometimes the corpuscles are not acted upon at all by the acid, appearing then to be of a fatty nature. A strong solution of caustic ammonia produces a concentrically laminated or fissured appearance in them. Under pressure and with commencing putrefaction, a number of them sometimes flow together into an irregular or rounded mass." In consequence of

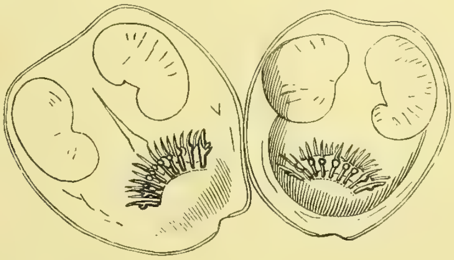

FIG. 57.—Two Echinococcus scolices, from an hydatid developed in the liver of a sheep; treated with acetic acid, and slightly compressed (× 220 diam.)—Busk.

these structural characters, the endocyst is sometimes denominated the cellular layer.

One of the most interesting physiological questions suggested by the peculiarity of these organisms, is that which has reference to the mode of development of the scolices, or so-called Echinococcus heads. Until very recently, this problem has not been satisfactorily solved; and even now, there are, of course, minor differences of opinion. The generally-received notion that the heads bud out stoloniferously, as it were, is altogether disproved; whilst the more ingenious views promulgated by Huxley are, I fear, almost equally incorrect.

To render a clear account of the history of the formation of the Echinococci it is necessary for me to remind the reader that the older authors supposed that in course of development the heads became detached from the endocyst, and escaping into the fluid interior of the cavity, swam about vigorously. Some, including Professor Owen, averred that these movements were brought about "by means of superficial vibratile cilia;" and many more supposed that their ulterior stages of development were completed whilst they were thus enjoying a free and active mode of existence. The stern realities of recently-discovered facts require us to dismiss all these, and many other equally incorrect views. Whether we have to do with simple isolated hydatids, or whether we have to deal with compound exogenous, endogenous, or multilocular formations, the developmental process is essentially the same in all cases, at least, in its main features. I shall now, therefore, give a brief description of the process, chiefly in accordance with the views promulgated by Leuckart, finally quoting from the same authority his own account of the variations of opinion which subsist between himself and other authorities.

The first indication (of what is subsequently to become an Echinococcus head, or a group of heads) consists of slight papilliform elevation at the inner surface of the endocyst. This prominence—which does not hitherto appear to have been recognized in

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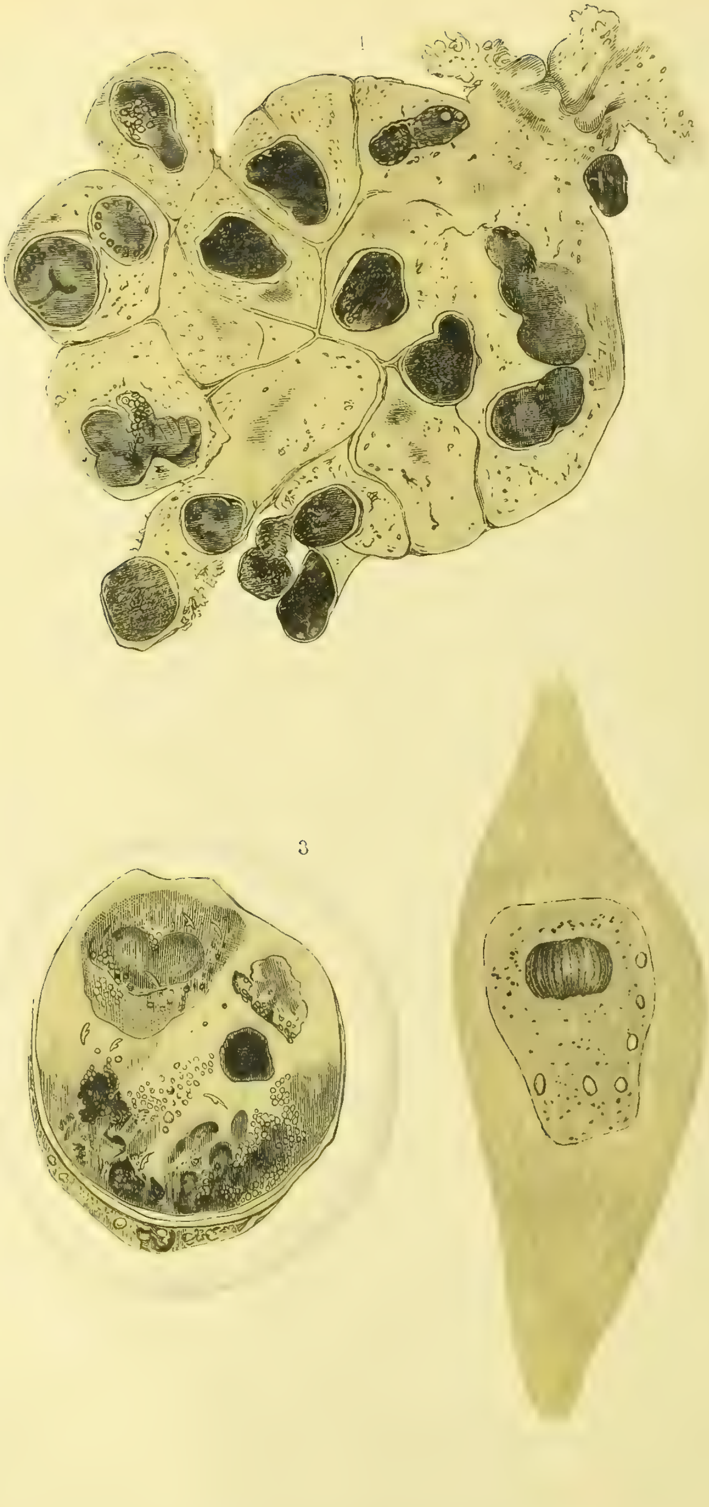

Echinococcus brood-capsule, immature scolex, and degenerating daughter-vesicle.

G. Busk, delt.

its very earliest stage—after a short while displays in its interior a vacuole-like cavity, the latter being occupied, however, with a clear limpid fluid. Its margins become more and more clearly defined until the cavity is by and by seen to be lined with a distinct cuticular membrane. The papilla increasing in size, becomes at first elongated or oval, eventually scoleciform, or even, perhaps, a true echinococcus head. Thus far, the description bears out, in a measure, the theoretical notions entertained by the older authors; but the developmental process does not stop here, and it is even a question if, in any case, it ever does so. The scolex-like development has now—possibly, it may be, not in every case —has now, I repeat, to sacrifice itself by developing in its interior a brood of scolices or echinococcus heads. In other words, it becomes gradually transformed into the so-called brood-capsules of Leuckart and other authors.* All observers who have microscopically examined fresh echinococci must have seen these capsules. Portions of the essential vital endocyst, here forming the outer wall of the brood-capsule, now thicken in the same way that the original maternal endocyst had done, and these thickened portions, in their turn, become true scolices, or, in some cases, scolicecoid formations. By a process of inversion—precisely similar to that which has been so often described and figured in the case of Cœnurus—the heads are withdrawn, as it were, into the cavity of the brood-capsule; and thus the latter display a bird's-nest-like appearance (Fig. 58). Frequently, however, a considerable number of them are seen everted, as is shown in one of the highly-characteristic figures given by Huxley in his memoir. In this way the developmental process is completed.

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* I adopt the term "brood-capsule" as eminently convenient and expressive; but I may observe that these sacs were well known to Wilson and Busk. The former spoke of the capsule as "*a delicately thin proper membrane*, by which the Echinococci are connected with the internal membrane of the acephalocyst" (Med.-Chir. Trans., 1845, Vol. xxviii., p. 21). Mr. Busk described the Echinococcus heads as "attached to a common central mass by short pedicles, which appear to be composed of a substance more coarsely granular, by far, than that of which the laminæ of the cyst are formed. This granular matter is prolonged beyond the mass of Echinococci into a short pedicle common to the whole, and by which the granulation is attached to the interior of the hydatid cyst." What Mr. Busk here describes as a granulation, can only be equivalent to the brood-capsule and its entire contents, but he elsewhere speaks of the capsule itself as a "delicate membranous envelope." It should be borne in mind that Mr. Busk's paper was communicated to the Microscopical Society so early as the 13th of Nov., 1844; being published in the Transactions for that year. The original series of this periodical is now very scarce.—T. S. C.

Before proceeding further, I may here remark that many modifications of this process have been witnessed as regards individual scolices, some of which abort, whilst others, possibly, become new or secondary brood-capsules. All those numerous instances where scolices have been seen free in the cavity of the capsules, or in the great general cavity of the maternal hydatid, or in the cavities of the (subsequently to be described) daughter and grand-daughter hydatids, are simply examples of morbid phenomena. They are, in other words, entirely due to *post mortem* changes. In this condition the scolices are generally quite dead, and therefore, assuredly, do not need a covering of vibratile cilia wherewith to execute their supposed swimming evolutions.*

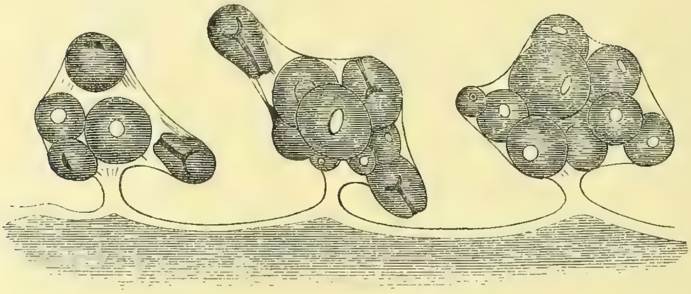

FIG. 58.—Series of brood-capsules with their contained Echinococci; from the human subject (× 76 diam.)—Wilson.

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* On one occasion, when engaged in dissecting an antelope (*Antilope quadricornis*) at the Zoological Gardens, a fellow-worker seized hold of an enormous solitary hydatid cyst with such vigour that the contents burst out with great force. My face, head, and neck were literally covered with myriads of echinococcus heads, and, not being then aware of their death, I felt afraid to speak lest I should swallow a few dozen of the scolices adhering to my lips. Though this was a false alarm, some of our breeding-experiments are highly dangerous, and I would particularly warn commencing investigators how they handle full-grown tapeworms.—T. S. C.

In the completely developed state, the echinococcus heads exhibit somewhat variable characters as to size and form, the latter differences being, for the most part, dependent upon their degree of contraction and vitality. In the fully evolved condition they vary from the $\frac{1}{60}''$ to the $\frac{1}{100}''$ in diameter, being usually about the $\frac{1}{18}''$. They are solid throughout, and now exhibit a more or less hourglass-like constriction at the centre of the body, which divides the scolex into an anterior part supporting the rostellum and suckers, and a posterior part which has been erroneously compared to the caudal vesicle of ordinary cysticerci. The rostellum supports a double crown of hooks, but the disparity of the two series is scarcely sufficiently marked to render their distinction readily obvious. The hooks of the smaller row vary in size from $\frac{1}{1040}$ to $\frac{1}{1780}$ of an inch, whilst those of the larger series are from $\frac{1}{830}''$ to $\frac{1}{1780}''$. In all instances, as shown by Leuckart, the root-processes are incompletely developed, and, consequently, also vary much in thickness. In some they exhibit peculiar abnormalities, and, on the whole, the echinococcus hooks may be said to be less perfectly formed, in any case, than obtains in the corresponding scolecine or cysticercal conditions of other tapeworms. As regards the other structural features of these larvæ, we find the suckers four in number, and the general aspect of the body finely granulated;

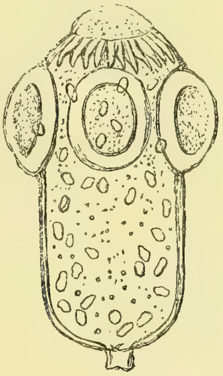

FIG. 59.—Isolated and unfolded human Echinococcus scolex, displaying the double crown of hooks, cephalic suckers, calcareous corpuscles, and caudal pedicle (× 300 diam.)—Original.

whilst the observer is invariably struck with the appearances presented by the highly refracting calcareous corpuscles, which more particularly abound at the parietes and inferior part of the scolex. On these bodies I need scarcely dwell, as I have already described their essential features when commenting on the structure of the *Cysticercus tenuicollis*. Their size varies, and in Huxley's hydatid, from the zebra, they presented an average of the $\frac{1}{2500}''$ only. Huxley even goes so far as to express his belief "that in the young and normal adult state, these peculiar corpuscles are never calcareous, but are composed of an albuminous substance." This notion, as to their earthy character being the results of a degenerative process, cannot, as I have said before, be maintained; notwithstanding, it is quite true that all the cestode larvæ exhibit a tendency to calcify, after they have passed the natural limit of their vitality.

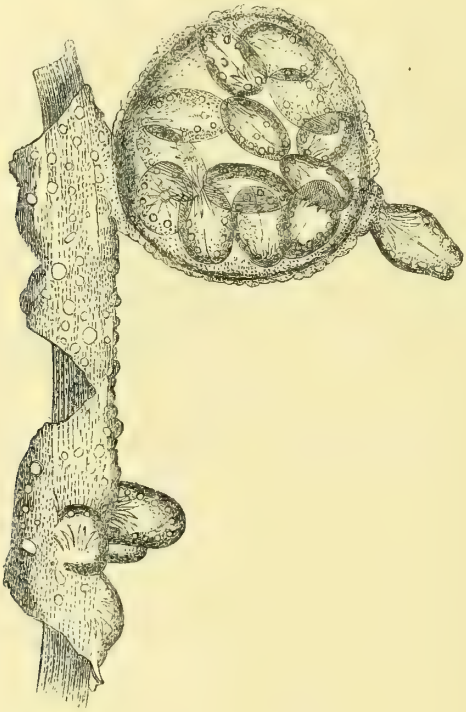

FIG. 60.—Portion of a daughter vesicle, or secondary cyst, showing "the relation of the endocyst to the laminated ectocyst" and the so-called Echinococci contained in a brood-capsule (× about 80 diam.) From a zebra.—Huxley.

Having no space to dwell further on this question, it remains for me to observe that a distinct water-vascular system is recognizable in these scolices, being also connected by the intervention of the stalk-like neck of the scolex, with the endocystic layer of the brood-capsule, and also, therefore, with the vessels of the maternal endocyst. In the scolex, according to Leuckart, there exists a circular channel immediately below the rostellum, and this ring, on either side, gives off two vessels which pass downwards in a tortuous manner on either side of the scolex, internally, until they arrive at the pedicle where they unite to form two channels, which latter are continued into the vascular system of the maternal endocyst. In the retracted condition of the scolex, their position, of course, becomes very much altered, and they form loops on either side of the central line which marks the space leading down to the now inverted head. Neither Huxley nor myself have seen these vessels in the scolex itself, but Huxley discerned some apparently loose cilia in the granular parenchyma of the body, the longitudinal measurement of these free filaments being about the $\frac{1}{3500}$ of an inch (Fig. 4, Plate XIII). Further into the morphological changes exhibited by the retracted scolices I need not enter.

But now comes the curious question respecting the singular phenomenon termed proliferation. Here, also, must I be brief, and, to avoid circumlocution, at once observe that the endocyst is, as recently shown by Naumyn,* primarily concerned in the production of the secondary and tertiary hydatids, whether they be exogenous or whether they be endogenous. In point of fact, they are special bud-developments which, instead of becoming brood-capsules, become daughter vesicles and grand-daughter vesicles, constantly developing in their interior secondary and tertiary brood-capsules and scolices, but sometimes, it would appear, developing neither the one nor the other. Without attempting a detailed exposition of all these singular and interesting phenomena, I shall adduce a lengthened passage from Leuckart, which will probably sufficiently unfold the complexities of the process. Referring to Naumyn's memoir (which I had myself previously consulted), Leuckart (at s. 752 of his work; bd. I.) makes the following comment:—"Before I enter," he says, "on the formation, more especially of the secondary so-called daughter bladders, I will just mention that Naumyn considers the echinococcus heads, as I have also done, as taking their origin, without exception, on the brood-capsules, and that in their normal condition they are always connected in one common system with the maternal hydatid. In this respect only is there any difference between us, namely, that Naumyn considers the hollow buds which adhere outside the brood-capsules to be inverted and only formed during the cooling of the echinococcus vesicle. In their normal condition the young echinococcus heads were to protrude into the cavity of the brood-capsule; consequently, they there developed themselves (as Wagener has also described) from the first, and in their subsequent state, with the cuticular layer outside. That both conditions may appear there can be no doubt, and I have particularly stated that I have sometimes found the whole of the buds inverted. In spite of this circumstance, I am inclined to consider my view, for the present, the correct one, and in opposition to the view of Naumyn, to consider the premature inverting as exceptional, partly on account of the analogy with the other bladder tapeworms, partly, also, because after the representation of Naumyn (and Wagener) not a single motive can be discovered for the development of echinococcus heads from hollow buds. If the heads were to bud freely in the cavity of the brood-capsules from the beginning, then one must explain their later solid formation from the commencement. I have never seen the cilia which, according to Naumyn, are situated on the inner surface of the mother bladders, as well as on the brood-capsules, but, in other respects, there are hardly any differences of opinion between us as regards the histology of these animals. The more striking, therefore, is the divergence of our views as to the daughter hydatids. It is denied (by Naumyn) that they take their origin between the lamellæ of the mother bladder, a fact, however, which in agreement with Kuhl and Davaine, I have seen more than once and have followed out step by step. The daughter bladders (not speaking of the common sprouting) are said to arise out of heads and brood-capsules which grow out gradually and bladder-like beneath the thickening and lamination of their cuticle. I have not the slightest doubt that the author has minutely watched these processes, and I rejoice myself to be able to confirm one method of this formation, namely, the bladder metamorphosis of the scolices (which was not only previously asserted by Bremser, but also by Von Siebold and Wagener). As the author has fully shown, the metamorphosis commences in the hinder part of the body, which, by the expansion of the inner cavity, swells into a bladder-like vesicle, drawing gradually the front part with its crown of hooks into it, and (by a thickening of the cuticle, as well as by the uniform distribution of the internal parenchyma) assuming more and more likeness to the echinococcus hydatid. Sometimes one sees developments which are only distinguished from the young echinococcus vesicles by the adhering remnants of the former crown of hooks."

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* "Dissert. Inaug. Berol." 1862, in "Archiv. für Anat. und Physiol.," 1862, s. 612.

I have purposely transcribed this passage *in toto*, because the subject of the development of these echinococci is not only one of considerable importance physiologically, but because there still remain several disputed points which it is quite possible we may soon be enabled to solve. Our best microscopic observers will here still find abundant room for further research. Reasoning from analogy as well as from personal observation, I am strongly of opinion that Naumyn's views will turn out pretty correct. With Huxley I still regard the endocyst as capable of forming solitary scolices. Some of the scolices become differentiated to form brood-capsules, a portion of whose individual echinococcus heads may, in their turn, become secondary brood-capsules, whilst others fail to become either scolices or secondary brood-capsules. It also accords more with our knowledge of the general plan of development to believe that the daughter and grand-daughter hydatids are likewise peculiarly modified scolices, in which case it is obvious that they must commence by a process of budding from the endocyst, as, in point of fact, Naumyn states they do. It does not seem probable that the secondary and tertiary hydatids should arise from independent granular points within the laminæ of the non-vital ectocyst. For the acceptance of my view it is not even necessary to perceive a thorough scoleciform character in the primary buddings destined to become daughter vesicles; it is sufficient if the original process of differentiation clearly resembles the papilliform commencement of the ordinary scolex head. Lastly, these views, suggested by the description of several authors (more particularly by those of Huxley, Leuckart, and Naumyn), will likewise hold good in every case, whether we have to deal with the compound exogenous, endogenous, or multilocular hydatid growths.

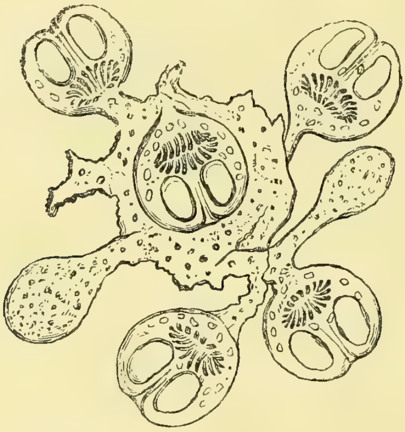

Fig. 61.—Portion of a ruptured brood-capsule, showing Echinococcus scolices somewhat flattened by pressure; from a Lemur (× 130 diam.)—Original.

In concluding this division of my subject, may I not congratulate physiologists upon the highly satisfactory position at which helminthologists have now arrived in regard to one of the most intricate and interesting questions which the subject of parasitology has evolved? It would please me well if I could here lay aside my pen, but I have yet to consider the echinococcus hydatids from a more purely practical and professional point of view.

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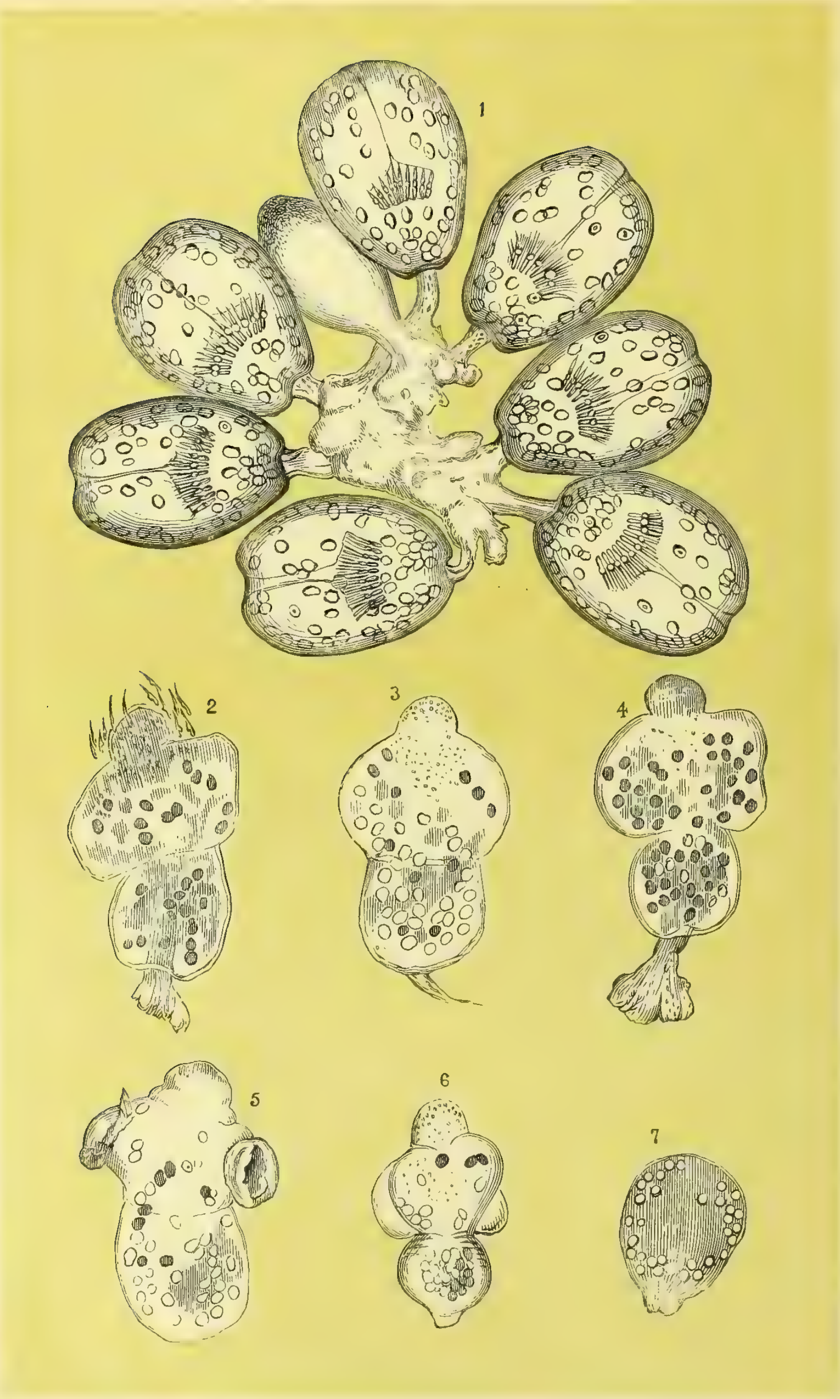

Scolices of Tænia echinococcus.

G. Busk, delt.

CHAPTER VIII.

TÆNIA ECHINOCOCCUS.

Hydatids considered from a professional point of view—Leuckart's condensed account of Virchow's so-called multilocular Echinococcus-growth—Its resemblance to alveolar colloid—Relative frequency of hydatids in particular organs—Results obtained by Rokitansky and Davaine—Cases recorded in English periodicals—Statistics—Statements of Krabbe and Schleisner—Diagnosis and treatment—Prevention.

From what has been already advanced, it is evident that the pathologist must be prepared to find a great variety of echinococcus hydatid forms in the human subject. He may encounter the solitary hydatid with its contained scolices, or a series of hydatids more or less widely separated from each other by intervening parenchyma. More commonly, he will meet with the endogenous multiple form, the original maternal cyst containing, it may be, only a few daughter vesicles, perhaps several score, possibly many hundred, in which latter case part of them will commonly include grand-daughter vesicles. Sometimes the secondary hydatids will develop scolices and grand-daughter vesicles before the original maternal hydatid has acquired echinococcus heads. In other words, the progeny of the maternal hydatid may arrive at maturity before the mother itself. Leuckart has seen this, and he has also seen instances where the daughter vesicles contained grand-daughter hydatids, although the former were only half an inch in diameter.

In addition to the above-mentioned kinds, one may occasionally, though rarely, come across the multilocular form of echinococcus, whose true nature was first described by Virchow. The English pathologist is already familiar with the characters of this growth, as they are given (chiefly from Virchow and Luschka) in Lankester's edition of Küchenmeister's well-known manual. As I have not yet had any opportunity of verifying the descriptions of these authors, I shall supplement them with the condensed account of this growth, as given by Leuckart, from the cases by Zeller and Virchow ("Die menschl. Par.," s. 370): "Hitherto we know this growth only from the liver, in which it forms a firm, solid, and tolerably rounded mass of the size of the fist or even of a child's head. At first sight, it looks more like a pseudoplasm than a living animal parasite. If you cut through the tumour, you recognize in its interior numerous small caverns, mostly of irregular shape, and separated from one another by bundles of connective tissue, more or less thick, and including a tolerably transparent jelly-like substance. In the intervening stroma, a blood-vessel or a collapsed bile-duct runs here and there; but there is nowhere any trace of true liver substance. The outer boundaries of the tumour are in most cases pretty well defined, so that the attempt to cut these growths out is not difficult. In particular spots, especially at the surface, one sometimes sees white, moniliform, jointed lines passing off from the tumour, and even thicker terminations which, perhaps, expand in the neighbouring liver-parenchyme into new (multilocular) groups of different size. In one case, recorded by Virchow, the growth extended, together with Glisson's capsule, a long way towards the intestine." To this description it may be added, that the growth on section presents an appearance not altogether unlike alveolar colloid, having, in point of fact, been confounded with that pathological product, with which, however, as stated by Virchow, it has nothing in common. This is proved not only by the occurrence of the pathological features above mentioned, but also, more particularly, by the well-ascertained presence of echinococcus heads in most of the so-called alveoli. Many hypotheses have been broached with the view of explaining the mode in which these multilocular hydatid growths are formed. I have neither space nor inclination to discuss the question fully, but I may briefly mention, in passing, that Virchow thinks the echinococcus vesicles are primarily formed in the lymphatic vessels, whilst Schröder Van der Kolk thinks that they originally take up their abode in the biliary ducts.

Turning now to some of the more practically important questions affecting the diagnosis and prophylaxis of hydatid formations, one naturally demands to know in the first instance, what is their relative frequency of residence in the different parts, organs, or viscera of the human body. On this point, from personal observation, no pathologist speaks with more authority than Rokitansky, according to whom their seat is prevalent in the following order:—1. liver; 2. subperitoneal areolar tissue; 3. omentum; 4. muscles of the heart; 5. brain; 6. spleen (generally associated with one in the liver); 7. kidneys; 8. lungs; 9. bones.

M. Davaine, who appears to have gone over the literature of this subject with extraordinary care, writes as follows ("Traité des Entoz," p. 375):—"In man the hydatids are found in all the parenchymatous organs, but with a very different degree of frequency. The liver, in itself, offers more cases of this affection than all the other organs put together. Often, when the hydatids exist in some distant parts, they are found at the same time in the liver. The lung takes the second place as regards the frequency of the hydatids; they are, again, rather common in the spleen, the kidneys, the omentum, (and) the brain. We are in possession of some examples from the spinal canal, from the eye, and also from the bones; it is scarcely more common to encounter them in the limbs and in the parietes of the chest and abdomen; the testicle, the ovary, the uterus, and the mamma are very rarely infected." The author then gives an approximatively correct analysis of all the cases quoted by him in his voluminous treatise; their total number amounting to 373. Their relative frequency of occurrence in the various organs stands as follows (the figures appended indicating the number of cases):—Liver, 165; lungs, 40; kidneys, 30; pelvis, 26; brain, 20?; bones, 17; parietes of the trunk, 12;

heart, 10 ; orbit, 9 ? ; breast, 7 ? ; soft parts of the thigh, 6 ; neck, 5 ? ; ovary, 4 ? ; spinal cord, 3 ? ; globe of the eye, 3 ?; pulmonary vessels, 2 ; pituitary body, 2 ; face, 2 ; mouth, 2 ; soft parts of the shoulder, 2 ; scrotum and testis, 2 ? ; supra-renal capsule, 1 ; vesicula seminales, 1 ; parietes of the uterus, 1 ; placenta, 1 ? Such is M. Davaine's analysis, which, notwithstanding all his care, must necessarily be imperfect, partly from the difficulty which many have experienced in ascertaining with precision the original seat of the hydatid growth, and partly from the probable inaccuracies of many of the records from other causes. He has also attempted an analysis of the 165 liver cysts ; 4 of these projected into the thoracic cavity ; 9 opened into the pleura ; 21 communicated with the base of the lung, or with the bronchi ; 8 (apparently) opened into the biliary passage ; 8 others into the cavity of the peritoneum ; 22 into the alimentary canal ; whilst the remaining 94 exhibited the more ordinary conditions. Imperfect as Davaine admits these records to be, they are nevertheless highly instructive, and cannot fail to convey a generally correct notion of the relative frequency of hydatids in the various parts of the body.

I have purposely arranged Davaine's cases in a somewhat different manner to the one he has adopted, in order that they may be the more readily compared with the table of Rokitansky, and also with the analysis I have myself made from cases recorded in our English periodicals. Altogether, at the present time, I have examined the records of 136 cases of hydatid disease published in the pages of the "Lancet," the "Medical Times and Gazette," the "British Medical Association Journal," and other well known professional serials—amongst the most valuable of which (in this relation) I take leave to particularize the Transactions of the Medico-Chirurgical and Pathological Societies.*

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* During the passage of this work through the press I have continued my labours in this direction, and have fallen upon several more cases, which cannot now be specially treated of. References to all of them, however, will be found in the Bibliography. —T. S. C.

From the variety of headings under which such cases are usually referred to in the indices of these works, I do not pretend to say that I may not have overlooked one or two valuable papers; whilst the occasional absence from our libraries of one or more volumes of certain serials, as well as other interfering circumstances, have prevented my becoming acquainted with all the cases which have been published in our journals within the last thirty years. Some few of these cases are included in the extended list given by Davaine; but the independent value of the record will not, I believe, be materially lessened on that account. My analysis of these cases stands as follows:—Liver, 51; abdomen (including those found in the peritoneal cavity, in the omentum, and in the intestinal canal), 19; brain, 16; heart, 8; lungs, 8; kidneys, 4; bladder and urine, 3; pelvic cavity, 3; tibia, 7; scapula, 1; frontal bone, 1; anterior condyloid foramen, 1; orbit, 1; spinal cord, 1; neck, 1; breast and arm (subcutaneous), 1; loin, 1; thigh, 1; under biceps femoris, 1; in biceps humeri and temporal muscles, 1; ovary, 1; blood, 1; pericardium, 1; diaphragm, 1; in a fœtus, 1. I think this analysis is tolerably correct, the only really doubtful figures being those indicating the number of the cases of lung and abdominal hydatids respectively. Where, in cases of recovery, some hydatids have been expectorated and others have passed per anum, it was, of course, impossible to determine whether or no these parasites had their primary seat in the liver. But, perhaps, the most interesting fact which I have noted in respect of these cases, lies in the circumstance that no less than thirty-five of them were cases in which the patients recovered. Four of these were complete natural cures; two others being also temporarily cured in the same way. All the rest were cured by surgical operations, but I fear only two of them were correctly diagnosed (*i.e.* with certainty) prior to the employment of the knife or trochar. Most of them were regarded as tumours or abscesses until the escape of their contents (from incision) had revealed their true character.

Without venturing to offer any particular account of the various interesting features which the above cases severally presented, it may be, at least, useful to refer, categorically, to the names of the authors who have placed the cases on record. Those who desire further information (as to certain cases) can easily obtain it by turning to the Bibliography appended to this work, where, under the appropriate names, they will find sufficiently minute references to the works in which the original descriptions are recorded. Thus, as regards hydatids of the liver and biliary passages, cases in which death occurred are given by Elliotson, Rogers, G. Budd, Hastings, Dickenson, Murchison, Buchanan, Barlow, Peacock, Griffith, Salter (two cases), Wilks, Bristowe (three cases), Pollock, Beith, Davies, Freer, Crosse, A. T. Thomson, H. Thompson, Hilton, Rees, Chambers, and Alison; also by Ingliot, Gulland, Luschka, Hellier, and Dupuytren. The thirteen cases in which a cure was effected either naturally or otherwise, are by W. Budd, Sloane, Peacock, Rees, Robarts, Hutchinson, Brodie, Cholmeley, Chereau, Richard, Recamier, Thorstensen, and Morrisseau. It deserves to be mentioned that the cases by Sloane and Hutchinson were accurately diagnosed. In the cases recorded by Richard and Recamier injections were employed, whilst, in many of the others, cures were effected by a simple incision. In all these instances, however, I believe the operators were uncertain as to the nature of the tumour they had to deal with; a persuasion which, if not incorrect, argues very little in favour of Piorri's so-called "hydatid fremitus" and other diagnostic symptoms.

Of the nineteen abdominal cases there were twelve which terminated fatally; these being recorded by Crowther, Bailey, Trimnell, Hughes, Newman, Morley, Greenhow, Jones, G. Budd, Ogle, Obre, and Angeli. The seven in which cures took place are by Gaitskell, Gregory, Greenhow, Adams, Bobillier, Roux, and Chaubasse. Several of these cures were entirely the result of natural causes. In the case by Gaitskell it is estimated that fully 1000 hydatids were discharged; and as they were accompanied by several biliary calculi, there can be little doubt that the original hydatid cyst had its seat in the liver. In the case by Chaubasse about 600 hydatids were evacuated from an abdominal abscess; whilst in the somewhat similar but fatal case by Crowther, it is averred that, in addition to numerous hydatids, the cyst contained upwards of six gallons of purulent matter.

The sixteen brain cases are by Bree, Berncastle, Barker, Bennett, Brittan, Bailey (two cases), Baillinger, Dagleish, Stewart, Wilson, Sturton, Montault, Guerard, Martinel, and Seville. These, of course, were all fatal. In the case recorded by the last-named author, the acephalocysts were situated immediately beneath the arachnoid membrane.*

In like manner, as will be supposed, the eight heart cases were all fatal. They are severally recorded by Wilks, G. Budd, Coote (two cases), Price, R. Smith, Trotter, and Vines. The single instance of hydatids occurring in the cavity of the pericardium is given by Habershon in the "Pathological Society's Transactions." Amongst the eight lung cases, but one cure appears to have taken place, and, in this instance, only a portion of the hydatid seems to have been expectorated. It is recorded by Hutchinson; the fatal examples being by Black, Bainbridge, Cholmeley, Rogers, Todd, Fouquier, and Dupuytren. The example of hydatids in the blood is by Klencke. The two spleen cases are both from foreign sources (by Goyrand and Legroux), as is also the instance where some two hundred hydatids occupied a cyst attached to the under surface of the diaphragm (by Pohl). All these were fatal. The four cases of hydatids affecting the kidneys are severally described by Barker, Ward, Dunn, and Fussell. That by Ward is a doubtful instance of cure; the others proved fatal. The three examples of echinococcus heads and hydatids from the urinary bladder are all from foreign sources (Quiquerez, Tomowitz, and Auglagnier). In the case given by the last-named author, seventeen hydatids were passed by the urethra. In this relation, I may also appropriately refer to the three interesting examples of hydatid formation occurring within the pelvis, or, more precisely, in the immediate neighbourhood of the bladder. These cases are by Lowdell, Farre, and Wakley. The one by the first-named author proved fatal, but timely operation saved the other two. In Wakley's interesting case, the sac contained a single hydatid as large as the egg of an ostrich. If I remember rightly, both Farre's and Wakley's cases occurred in women, a circumstance which derives additional interest from the fact that Dr. A. T. Thomson has recorded in the pages of the "Lancet" a genuine case of hydatids simulating ovarian disease.

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* Dr. William Anderson, L.R.C.S.E., Resident Physician at the Birmingham General Hospital, has recently favoured me with a communication in which he states that he has met with no less than *four* cases of hydatids of the human brain, in each of which he succeeded in demonstrating the presence of hooks after death. In two of the cases "the diagnosis was given with tolerable certainty." I need hardly add that I look forward, with great interest, to the publication of these cases.—T. S. C.

Amongst anonymously recorded cases, I find one where hydatids existed in the spinal canal, and another where a solitary acephalocyst, lodged within the orbit, had produced exophthalmia. My colleague, Mr. Hulke, has met with a similar case, and a third example has been brought under my notice by Mr. J. Jardine Murray, of Brighton.

Very peculiar and diversified, as to situation, are those cases where the hydatid cysts occupy the external soft parts of the trunk and extremities. Thus, Dixon describes an instance in which a cyst containing several hydatids occupied the root of the neck. Dupuytren cured one patient who had an hydatid cyst situated, it is said, in the anterior condyloid foramen, causing atrophy and paralysis of the tongue by pressure on the lingual nerves; and he operated on another patient who had hydatids in the biceps (humeri) and temporal muscles. Two equally interesting cures are also recorded in our English journals by White and Bryant. In the former case (reported by Mr. Aitkin) the hydatids were situated in the breast and arm, whilst Bryant's large hydatid tumour occurred between the adductor muscles of the thigh. In another case of cure by operation (Jackson) the tumour was seated in the loin.

Excluding the remarkable case of Œsterlen, reported in the "Medico-Chirurgical Review" (where an extraordinary enlargement of the kidneys took place in a fœtus from the development of hydatids within their substance), the above, with one or two exceptions, comprise all the interesting cases I have met with where those singular formations occupied either the viscera or external soft parts of the human body. (I am speaking, of course, more particularly with reference to our home *periodical* literature.) There remain, however, four other cases, of especial interest from the circumstance of their occurring in connection with the osseous system. One of these, no doubt, originated independently of the bone. I allude to the case operated upon by Sir Benjamin Brodie, in which the hydatid cyst was situated in the region of the scapula; but I mention it, in this place, because a very similar case occurred to M. Roux at La Charité (1826) with the following curious features:—The tumour was supposed to be a large abscess, but after making an incision, M. Roux discovered that he had encountered an hourglass-shaped hydatid cyst, the constricted portion of the tumour being surrounded by the circular border of a round hole existing in the scapula ("Lond. Med. Repos.," p. 187).

Lastly, in regard to genuine *bone* cases, it cannot but be looked upon as rather singular, that, in the instances which I have here collected, the hydatids, with one solitary exception, occupied the shaft of the tibia. These English cases (including one American) are seven in number, and may be referred to under the names of William Hunter (Museum specimen), Astley Cooper, Webster, Wickham, Coulson, Lambert, and H. Thompson. The first five of these are included in M. Davaine's list of six cases; so that only one similar example has apparently been met with in France.* When Coulson's comparatively recent case was first reported, the example was regarded as unique; but it now turns out that the occurrence of hydatids within the tibia is much more common than obtains in the case of any other bone in the system. Truths of this kind should, in future, suggest a caution to those who may happen to meet with cases which, in the first instance, are deemed rare or altogether unique; but, at the same time, it should encourage others who may meet with cases, which are not at first deemed rare or unique, at once to place them on record for the benefit of the profession generally, and of helminthologists in particular. Altogether, M. Davaine collects seventeen bone cases, the remaining eleven being as follows:—One from a phalanx of the index finger, two from the femur, one (rather doubtful) from the temporal bone, two from the frontal, one sphenoidal, and two others from the bones of the pelvis. One of the frontal cases is from an English source, being recorded by Keate in the tenth volume of the "Medico-Chirurgical Transactions."*

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* It is by Cullerier. See Davaine, l. c. p. 552; also "Journ. de Med. Chir. et Pharm." de Corvisart, etc., vol. xii., p. 125.

Statistics.—Another important aspect in which this subject may be viewed, has reference to the relative abundance of hydatids, in particular localities, and amongst different classes of people. The endemic character of the echinococcus disease in Iceland is well known. Thus, on the authority of Krabbe, a distinguished disciple of the recently deceased *savant* Eschricht, Leuckart remarks as follows:—

"For every 100 inhabitants of Iceland there are 1100 head of horned cattle, and every peasant has on an average six dogs. In Denmark there are 180 cattle to every 100 of the people. There are many of the Iceland doctors who, not unfrequently, have upwards of 100 patients (afflicted with the echinococcus disease) under treatment at the same time, the total number of such cases in the island being estimated at 10,000. By far the greater number of these patients, however, are in the hands of quacks, whose influence is the greater, because there are in all Iceland but *six legally authorized medical men*, each of whom presides over a district of about 1500 square (English) miles, embracing a population of about 10,000 individuals. The treatment of the quacks is exactly suited to keep up the epidemic, for, *amongst their remedies, dog's urine and fresh dog-excrement* play a conspicuous part.*

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* Highly interesting and instructive as these statistical records must necessarily prove, one cannot but express a regret that there should be so many intelligent practitioners who refuse to place their cases on record; for, by this negligence we are deprived of an immense amount of valuable information. No excuse need be advanced on their behalf, seeing that our public journalists are always ready to insert such cases, *provided only the communications be brief.* In going over our literature, I have been positively startled at the paucity of recorded cases of entozootic disease as compared with their actual prevalence in practice. For my own part, I would feel grateful to any of my professional brethren who would take the trouble to furnish me with a list of the *unpublished* cases which they have encountered from time to time in the course of their arduous duties. I am sure many gentlemen have notes of such cases, especially, for example, cases of *Lumbricus*, stored up either in MS. or in the tablets of their memories. I may add, however, that, since the above was written, I have met with several more cases of hydatids both in our periodicals and in various miscellaneous treatises. As these additions do not materially affect the general statistical result, I am content to offer references to them in the Bibliography at the end of this work.—T. S. C.

These statistics are sufficiently appalling; but they are entirely in accordance with the original statements of Schleisner, who, in a record of 2600 cases of general disease, found 328 of them due to hydatids; whilst, out of 327 patients which came under his own immediate observation, 57 were suffering from the echinococcus malady. He found the disease more common in the interior of the country than near the coast; an experience which coincides with the well-known (and easily explained) circumstance that sailors are singularly free from hydatids. Schleisner gives the following table of the 385 cases above mentioned:—

Age.	Males.		Females.	
	Number.	Per centage.	Number.	Per centage.
0 to 1	0	0·0	0	0·0
1 „ 10	13	7·5	13	6·1
10 „ 20	18	10·4	14	6·6
20 „ 30	22	12·7	39	17·9
30 „ 40	38	22·0	47	22·2
40 „ 50	36	20·8	64	30·2
50 „ 60	27	15·6	22	10·4
above 60	19	10·9	13	6·1

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* "Die neuesten Entdeckungen uber menschliche Enigeweidewürmer und deren Bedeutung für die Gesundheitspflege." Convers. Jahrb. 1863, s. 654.

If this table be correct, the disease is much more prevalent in women than in men; the explanation of which must be sought for in the difference of their habits of life. No doubt, the water used as drink by the women, is constantly obtained from supplies in the immediate neighbourhood of their dwellings, and in localities to which dogs have continual access; moreover, the women, probably, obey more implicitly the dictates of the "quacks" who supply them with the filthy medicines above-mentioned. (For reference to Schleisner's work, see Bibliography.) The comparative rarity of the echinococcus disease amongst sailors is, according to my views, not so much dependent upon the circumstance that the seamen's diet usually consists of salted provisions, as upon the fact that these men can seldom have opportunities of drinking water from localities where dogs abound. Let uncompromising teetotallers beware how they condemn those who add a little wine "for their stomach's" or, rather, for their liver's sake. It may, indeed, be questioned if the addition of a little alcohol would destroy the six-hooked embryos of *Tænia echinococcus* whilst still *in ovo;* but, on the other hand, there can be no doubt that water raised to a temperature of 212° Fahr. will always insure the destruction of these parasite-larvæ. Boiled water by itself, however, is by no means palatable. The reason why the upper classes so seldom, comparatively speaking, suffer from hydatids, may be attributed to the circumstances, that those few who drink water take the very proper precaution to see that it is either "pump" or fresh spring water—the latter is not absolutely safe—whilst the majority partake of beer or porter, in which (even if the water employed in the brewing-process should be impure) no living six-hooked embryos are likely to exist. So far then as hydatids are concerned, beer-drinking, on the whole, is preferable to water-drinking; if, however, the so-called Adam's ale is filtered and pure, no evil can possibly result from its moderate imbibition.

Diagnosis and Treatment.—One need say little as to the methods of detecting the presence of hydatids. Only a comparatively few cases are known where the diagnosis has been effected with absolute certainty. No doubt the presence of a fluctuating tumour, without concomitant inflammatory symptoms, especially if it be seated in the region of the liver, together with the circumstance of its slow growth unattended with any particular degree of functional disturbance, would, to most minds, suggest the possible and probable presence of one or more hydatid cysts. Then there is the so-called "hydatid fremitus" of Piorri, which can scarcely differ from the ordinary impulse communicated by fluid matter within any other kind of tumour. Generally speaking, the accidental discharge, or the escape of one or more acephalocysts after incision, constitutes the only absolutely certain diagnostic symptom.

As regards their treatment—supposing a satisfactory diagnosis to have been accomplished—this, of course, in ninety-nine cases out of every hundred, has reference to the speedy evacuation of the contents of the tumour. A great deal of nonsense has been written about particular drugs, whilst the use of electricity has been warmly advocated by a few. Those who desire further ideas on this score may possibly derive advantage from consulting Davaine's treatise; but in the words of Dr. Todd (who wrote on this subject in 1851), I may say that "I know of no cure for hydatids but the evacuation of them. There is a popular notion that salt will kill the hydatid. Iodide of potassium has also been frequently tried, but I have never seen any real benefit from the use of these remedies." To this it may be added that the employment of a trochar for evacuation of the hydatid contents, and the subsequent injection of iodine, is a plan which has several times proved successful. In those cases, however, where a serous cavity intervenes between the cyst and the surface of the skin, the most serious mischief may accrue from the escape of some of the hydatid fluid into the cavity. M. Boinet and others have pointed out the proper precautions to be observed in such cases; but for these and all similar particulars, whatever their value may be, I need only refer to the excellent French work by Davaine, which I have ofttimes previously cited.

Prevention.—As prophylactic measures are necessarily better than cure, I invite particular attention to this department of the subject; desiring, in an especial manner, to impress upon all sections of the social community a few hints, which, if taken in good part, and subsequently acted upon, cannot, in my opinion, fail to be productive of useful results. Only a few years back, Dr. Todd remarked that there was no subject more obscure than the origin of these hydatids; but enough, I trust, has been now unfolded to show how wide an advance we have now made in this respect. Consequently, therefore, were are in a position to offer the most satisfactory advice as to the best methods of checking the prevalence of these larval parasites. We are not, it is true, able to bring about the total abolition of this terrible echinococcus disease; but, I repeat, we may check it to a noteworthy extent. Indeed, I believe the good offices of sanitary commissioners, as regards the habitations of the poor, and the general enforcement of cleanliness, so strongly insisted upon of late at social science meetings and other gatherings, have already done essential service, in more ways than one. To descend to particularities, however, Leuckart has made some admirable remarks on this head. Speaking of the relations which subsist between dog and man he says:—"In order to escape the dangers of infection, the dog must be watched, not only within the house, but whilst he is outside of it. He must not be allowed to visit either slaughter-houses or knackeries, and care must be taken that neither the offals nor hydatids found in such places are accessible to him. In this matter the sanitary inspector has many important duties to perform. The carelessness with which these offals have hitherto been disposed of, or even purposely given to the dog, must no longer be permitted, if the welfare of the digestive organs of mankind are to be considered. What blessed results may follow from these precautions may be readily gathered from the consideration of the fact that, at present, almost the sixth part of all the inhabitants annually dying in Iceland, fall victims to the echinococcus epidemic. It is true, that nowhere else, probably, are the conditions for the development or, rather, the transportation of the echinococci, so favourable as in that country. As the dog is of far greater importance to the Icelander than it is to us, the animal is, consequently, much more generally kept. Another circumstance, also, must be held to weigh very heavily, namely, that almost everybody in Iceland keeps his own stock of cattle, and lives, during the long winter nights, with the entire living stock, usually huddled together in a very small space. Moreover, that cleanliness which we know to be one of the most important preservatives against infection, is but too often wanting in those parts." (Jahrb. *loc. cit.*, s. 654.)

Similar prophylactic measures were long ago insisted on by Küchenmeister, but as his sentiments were expressed in a tedious and diffuse style, so characteristic of his writings, they did not, perhaps, receive that consideration to which they were undoubtedly otherwise entitled. In effect, he says that the principal thing to be done consists in the destruction of the echinococcus vesicles, combined with the expulsion and annihilation of the Tænia from the dog. In order to carry out this latter point, it was subsequently suggested by Dr. Leared that every dog should be efficiently physicked at a certain given time, and that all the excreta, tapeworms included, should be buried at a considerable depth in the soil. The experiment should be extended over several seasons. The mature *Tænia* thus destroyed would, it is conceived, cut off the supply of embryos and *Echinococci*, and the endemic might thus be averted. To this I would add, that in place of burying the excreta, *they should, in all cases, be burnt.* If this latter suggestion be not carried out, it is more than probable that multitudes of the minute embryos will escape destruction, and ultimately find their way into the human body. I have previously urged this preventive measure (in my paper "on the *Sclerostoma* causing the gape-disease of fowls," published in the "Proceedings of the Linnean Society" for

1861), with the view of lessening the prevalence of other entozoa, both of man and animals, and I again invite attention to the importance of observing this rule. *All entozoa which are not preserved for scientific investigation or experiment should be thoroughly destroyed by fire, when practicable, and under no circumstances whatever should they be thrown aside as harmless refuse.* In the case of the *Tœnia echinococcus*, the greatest difficulty likely to be experienced lies in the fact of the extreme smallness of this tapeworm. As an additional security, therefore, I would recommend that boiling hot water be occasionally thrown over the floor of all kennels where dogs are kept, for in this way, not only the escaped tapeworms, but also the little free embryos themselves would be effectually destroyed.*

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* These prophylactic measures were first advocated at the Cambridge Meeting of the British Association for the Advancement of Science, in 1862, and afterwards more fully developed in my paper communicated to the Zoological Society, and published in their Proceedings, vol. xxx., pt. 3, pp. 288—315. They have since been re-stated in the pages of the "Intellectual Observer;" and also, with approval, by Dr. Aitken, in the second volume of the second edition of his valuable work on "The Science and Practice of Medicine," p. 110.

CHAPTER IX.

BOTHRIOCEPHALUS LATUS.

General and specific characters of *Bothriocephalus latus*—Its geographical distribution—Anatomy and development—Investigations of Schubart, Knoch, and Leuckart, respecting the ciliated embryo—The adult worm occasionally found in dogs—Probable source whence the larvæ are obtained—Mode of egg discharge—Leuckart's account of a second species of Bothriocephalus infesting the human body.

Dismissing the *Tæniæ*, properly so called, I must now devote a brief chapter to the consideration of a small but interesting group of human cestodes, presenting, indeed, a very general resemblance to ordinary tapeworms, but differing from them in a most marked manner as regards their intimate structure. Until comparatively recent times, the *Bothriocephali* were regarded as species of the genus *Tænia*, and, even now-a-days, one occasionally meets with disciples of the old school who persist in employing the ancient Linnean title of *Tænia lata* to indicate the broad tapeworm as distinct from the common *T. solium*. The synonymy of the first species of this group is probably as follows :—

18. Bothriocephalus latus.

B. latus, Bremser ; Blainville ; Rudolphi ; etc.
Dibothrium latum, Diesing.
? *Tænia lata*, Linneus ; Pallas ; Bloch ; Goeze ; etc.
? *T. vulgaris*, Linneus ; Werner ; Retzius ; Gmelin ; etc.
T. dentata, Batsch ; Gmelin.
T. tenella, Pallas ; Retzius.
T. grisea, Pallas ; Schrank.

T. membranacea, Pallas ; Batsch.
T. humana inermis, Brera.
T. (à anneaux courts), Bonnet.
T. (sans épine), Andry.

General and Specific Characters.—The largest cestode helminth at present known to infest the human body, attaining a length of more than twenty-five feet, and sometimes measuring nearly an inch in breadth; the so-called head $\frac{1}{25}''$ in width, bluntly pointed at the tip, much elongated or club-shaped, slightly flattened from behind forwards, and furnished with two laterally disposed slit-like fossæ or grooves, but destitute of any armature: anterior or sexually-immature segments of the body extremely narrow, enlarging in a very gradual manner from above downwards; joints of the lower half of the body gradually decreasing in width, but enlarging in depth; sexually-mature segments usually about $\frac{1}{8}$ of an inch in depth, but those near the caudal extremity frequently $\frac{1}{4}''$, and quadrate in form; body flattened, but not so uniformly as obtains in the ordinary tapeworms, being rather thicker near the central line; total number of joints estimated at nearly 4000, the first sexually-mature ones being somewhere about the six hundredth from the head (Leuckart); reproductive orifices at the central line, towards the upper part of the segment at the ventral aspect, the vaginal aperture being immediately below the male outlet, and both openings surrounded by papillæform eminences; uterus consisting of a single tube, often seen regularly folded upon itself, forming an opaque, conspicuous, centrally-disposed rosette-like mass; eggs oval, measuring $\frac{1}{350}''$ in length by $\frac{1}{550}''$ in breadth, having three shell-coverings, and a lid-like operculum at one end, as occurs in the fluke-worms.

The extreme rarity of the occurrence of this cestode in England has hitherto prevented our paying much attention to the study of its structural and other peculiarities; consequently, our information is, for the most part, due to Continental observers and especially to Eschricht, Küchenmeister, Leuckart, and Knoch. Specimens, indeed, exist in our museums, but in those few cases where they have been obtained in this country, it has generally, if not invariably, happened that the individuals bearing them have come from other quarters of Europe. Thanks to the liberality of Leuckart, who has forwarded me various preparations, I have recently had ample opportunity of confirming many of the anatomical details which he has himself described; and I may also mention that there is a remarkably fine but incomplete specimen of this worm in the Middlesex Hospital Museum.

One of the most interesting points connected with the natural history of the *Bothriocephalus latus* has reference to its distribution (laterally) in space. It does not appear to have been seen in any non-European country, except in those instances where individual bearers have carried the worms away with them into foreign lands. Thus, Weinland, when recording his observations on the occurrence of *Bothriocephalus latus* in the American states, amusingly says, "We have seen two specimens of this worm in this country.

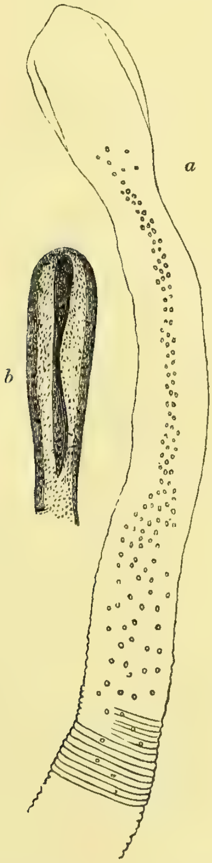

FIG. 62.—Head of *Bothriocephalus latus*; *a*, front view, showing the neck and anterior immature segments; *b*, lateral view, displaying one of the bothria. (Considerably enlarged).—Knoch.

The first was expelled from a Swiss soon after his arrival. The second was from an Englishman, in Richmond, Va., who had, perhaps, travelled in Switzerland, and, like the German anatomist and physiologist, Soemmering, and many other travellers, brought away with him this *vade-mecum* from the land of William Tell. We have never yet seen a specimen which came from an American, nor has Professor Leidy of Philadelphia, as he informs us by letter."* This statement of Weinland is also borne out by the records of other observers.

Speaking, more precisely, with reference to the actual geographical distribution of this parasite, Leuckart says that, even as regards Europe, it is only in certain districts that it is normally present. " Foremost amongst these are the cantons of West Switzerland, with the adjacent French districts. In Geneva, according to Odier, almost a fourth part of all the inhabitants suffer from Bothriocephalus. It is also common in the north-western and northern provinces of Russia, Sweden, and Poland. In Holland and Belgium it is likewise found, but on the whole, not so frequently in these first-named countries. Our German fatherland also harbours them in some districts, especially in Eastern Prussia and Pomerania, and there have appeared cases in other places, as in Rhenish Hesse, Hamburg, even in Berlin, these being apparently spontaneous instances. The same has been said of London, St. Malo, Montpelier, Rome, Zurich, and so forth." Of course, some of these supposed cases are doubtful; but, at all events, the distribution here recorded is tolerably accurate, and at the same time highly suggestive. The *Bothriocephalus latus* would seem, indeed, to be most common where the *Tœnia solium* is comparatively rare, but from this consideration alone we are scarcely entitled to look upon it as a representative species of the latter. At present, our knowledge of the history of its development is incomplete ; but sufficient, at least, has been accomplished to enable us to set aside the erroneous notions advanced by Vogt and others as to its mode of introduction into the human body.

Anatomy and Development.—Our information respecting the structure of *Bothriocephalus latus* is chiefly derived from the writings of Eschricht ; whilst that of its development is obtained from Schubart, Leuckart, and Knoch. From the asseverations made in a magnificent-looking brochure recently issued by the last-named author, and especially from previous statements published by this observer (" Petersburger medicinische Zeitschrift," 1861, No. 3) one was, in the first instance, led to believe that the whole mystery had been cleared up, but on looking closer into the matter, it unfortunately turns out that there are still many links wanting to complete the chain of evidence, and that Knoch's conclusions are in many respects erroneous. Whilst waiting patiently for the " missing links," we may, in the meantime, rely upon the correctness and importance of the following ascertained facts :—

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* "Essay on the Tapeworms of Man," p. 59.

The dark-brownish coloured eggs, which, from their oval figure and lid-like operculum at one end remind us of the ova of the common fluke, do not appear to be capable of developing an embryo in their interior, until they have escaped from the parent and have been immersed in water for a period of from four to eight weeks. More or less speedily, after the expiration of this variable period, the opening of the lid permits the escape of a fully developed ciliated embryo, which, after the rotatory fashion of Volvox, swims about for several days—from four to six, according to Knoch—whereupon, the ciliated covering bursts, so as to allow of the escape of a six-hooked, non-ciliated embryo. In Knoch's opinion this bursting of the ciliated covering is to be regarded as a sign of miscarriage on the part of the embryo; but, with more show of probability, Leuckart, on the other hand, regards this

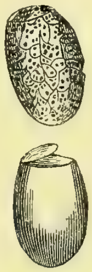

FIG. 63.—Two examples of the egg of *Bothriocephalus latus*; the upper one showing a finely segmented yelk, which, in the lower specimen, has escaped (X 250 diam.)—Leuckart.

escapement as a normal condition of things. I believe Schubart and Von Siebold were among the first to observe the ciliated character of the Bothriocephalus-embryos; but these organisms have since been very carefully studied by several observers. The embryos present a remarkably attractive appearance, in consequence of the unusual development of the cilia, combined with the general transparency of the other embryonic coverings. There are, in point of fact, three distinct membranes; an external one bearing the cilia, an intermediate one forming the capsule of the embryo, and an inner integumentary membrane, proper to the six-hooked embryo itself. Through all these coverings, the six boring-hooks are easily seen, situated near one pole of the body; all of them resemble one another, but in other respects they conform to the characters ordinarily exhibited by the cestode proscolices. According to Knoch, the hooks are about the same length as the cilia; but Leuckart has shown that this is an error, the cilia being at least three times longer than the hooks. After the disappearance of the ciliated covering, the last-named observer had occasionally noticed certain natural movements of the hook-apparatus, from which, of course, it might be inferred that the embryos were alive and ready for their passive transference into the body of some intermediate host. What this particular kind of host may happen to be is not yet satisfactorily determined. Knoch, indeed, would have us to believe, that in the case of *Bothriocephalus latus* there

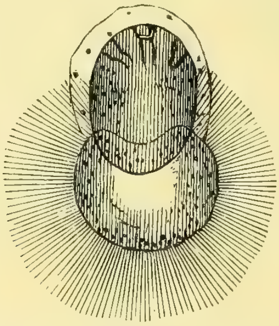

FIG. 64.—Six-hooked embryo escaping from its ciliated covering.—Leuckart.

was no need for any intermediate bearer; for, says he, in effect, I have succeeded in rearing young Bothriocephali, directly from embryos administered to dogs. That Knoch has succeeded in procuring young sexually immature *Bothriocephali* from dogs, no one need entertain any doubt; but to affirm that these were developed as the result of his administrations is quite another matter. He appears to have been unaware of the circumstance that examples of this worm are occasionally found in the dog. On this point Leuckart remarks, that "according to Pallas the *B. latus* is not rare in the dogs of Southern Russia, whilst Von Siebold says he has received it also from a dog in Pomerania.* Linneus had made similar communications previously, but he supposed that the Swedish dog-tapeworm was not referable to *Tænia lata* but to *Tænia vulgaris;* the latter being, possibly, identical with our *B. cordatus*, which, as we shall see, is more frequently found in the dog than in man." Notwithstanding Knoch's conclusions, therefore, we cannot bring ourselves to believe in the notion that the *Bothriocephalus latus* is capable of development without the aid of the ordinary intermediate host. If one may be permitted to hazard a conjecture as to the nature of this host, I should, on independent grounds, look to certain species of fish, and, especially, as Leuckart also has suggested, to the salmon and trout family. Küchenmeister's idea that the scolex or hydatid condition of this cestode may be found in certain species of Limax is not all convincing; yet, it is not impossible that they may occur in the bodies of fresh-water molluscs or other aquatic animals belonging to the articulate class. I repeat, however, my strong persuasion, that people infest themselves with this parasite by eating imperfectly cooked fish, in which the Bothriocephalus larvæ have taken up their temporary abode. In this connection, moreover, it is not uninteresting to remark, as Weinland has likewise done, that Creplin once discovered a Bothriocephalus in a cat—a circumstance which led him to conclude that it had been accidentally introduced by the animal's "eating fish containing the larva of that worm."

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* Professor J. B. Simonds, of the London Veterinary College, informed me, some time ago, that he had obtained a well-developed example of *Bothriocephalus latus* from an English dog; and I have since had an opportunity of examining the specimen, which is preserved in the College Museum.

As regards the structural peculiarities of the adult Bothriocephalus, I need only dwell upon those which are more obviously characteristic, inasmuch as I have already enumerated those of a general nature. In the living condition, the body of the animal is highly contractile, especially in the region of the so-called head; the latter orgān altering its form very materially at different times. Unlike ordinary cestodes, the *Bothriocephalus latus* very seldom breaks up into separate fragments, and never, apparently, into independent living proglottides. The integument presents nothing peculiar; and, according to Leuckart, the muscular layers are feebly developed, only a few calcareous corpuscles being scattered about the parenchymatous substance, here and there. The tissues of the body generally are remarkably transparent, the external parenchyma displaying "numerous rounded granular masses, which appear as opaque points," and impart to the tissues a yellowish grey colour. In each segment a well-defined internal membrane separates the central visceral mass from the surrounding external parenchyma of the body. The water-vascular system (as Eschricht long ago pointed out) is characterized by two main longitudinal channels, from which no transverse canals have yet been seen to pass off; but Knoch affirms that throughout the segments there is a superficial vascular network, which communicates with the great longitudinal vessels; and he has, moreover, observed granular movements in their interior, which he believes to be due to the presence of cilia. The main canals lie midway between the lateral borders and the central axis of the body, and, according to Von Siebold, terminate in the head by dividing into several fine branches.

Speaking generally, the disposition of the reproductive organs internally corresponds in a great measure with that of the Tæniæ proper; but the absence of a common cloaca and the consequent independence of the male and female orifices, forms a striking external difference. The upper or male orifice is mostly surrounded by a marked oval swelling, which is due to the enlargement of the so-called cirrhus-pouch; but, in place of a true penis, an intromittent organ is formed out of the walls of the highly extensile seminal duct, which is often conspicuously prolapsed. According to Leuckart, the precise nature of the connection between the *vas deferens* and the excretory ducts of the numerous pale yellow-coloured, testicular sacs, is at present not fully made out; yet one may safely affirm that, for the most part, the same arrangements obtain here as are known to occur in other cestodes. Again, as regards the female organs,—whose outlet is placed immediately beneath that of the male organs,—the uterus, as we have seen, consists of a simple tube folded upon itself, so as to form on either side of the central line four or five club-shaped processes, which, in their entirety, present an irregularly petaloid appearance. The older helminthologists, consequently, compared them to flowers or heraldic lilies; whilst the term "uterine rosette," which we now employ, is equally characteristic. The posterior end of the uterus suddenly narrows to form a channel, described by Eschricht under the title of "twisted coil" (Knäuel). It usually contains a number of yelk-granules and immature eggs, and, as Eschricht pointed out, is probably concerned in the secretion of the brown-coloured chitinous shell of the ova. Below this com-

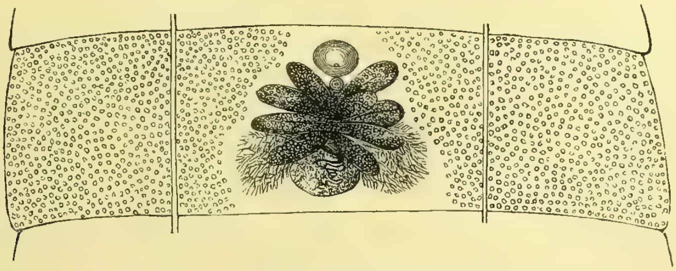

FIG. 65.—Section of the strobile of *Bothriocephalus latus*, showing the uterus, ovary, yelk-glands, and separate reproductive orifices. (Enlarged.)—Leuckart.

mencement of the uterine canal is a large oval body, considered by Eschricht to be glandular (Knäueldrüse), but which Leuckart, with more correct definition, denominates the ovary. Its connection with the vitelligene glands on either side, though not fully established, seems to be very similar to that which obtains in the tapeworms generally.

Finally, it only remains for me to add, that the ova do not escape after the ordinary method, but by the bursting of the overdistended uterus when the joints are sexually mature. This mode of egg-discharge though, to a certain extent, peculiar, occurs in several other cestodes, and likewise in other kinds of entozoa, as, for example, in the nematode species called *Sclerostoma syngamus*. It is not common, therefore, in full-grown *Bothriocephali* to find a whole series of joints thus lacerated, and emptied, more or less completely, of their egg-contents. There is also another peculiarity which affects this species even more strikingly than it does the *Tænia mediocanellata*. I allude to its tendency to form monstrosities. The occurrence of segments with double sexual openings is so extremely common that Leuckart avers that he has scarcely examined a single specimen of *Bothriocephalus latus* without detecting evidences of this strange malformation. The abnormality, moreover, is not confined to the external parts, but affects the internal organs; so that, according to Leuckart's interpretation, we have a double series of joints placed side by side, their outer halves becoming well developed at the expense of the conjoined and atrophied inner ones. Sometimes, indeed, one lateral segment altogether dwarfs its neighbour, adding confusion to the other irregularities.

19. BOTHRIOCEPHALUS CORDATUS.

B. cordatus, Leuckart.

This species is new to science, and has only very recently been described by Leuckart, who received about twenty specimens from the eminent naturalist, Professor Steenstrup. These examples were obtained at Godhaven, North Greenland, and were transmitted to Steenstrup by the Danish inspector, Counsellor Olrik.* Only one of the worms (about a foot long, or twenty-six centimetres) came from the human body, all the others being from dogs, in which animal it exists in considerable numbers. It differs from *Bothriocephalus latus* chiefly in the form of the head, which is heart-shaped (or, rather, obcordate), short and broad, and set on to the body without the

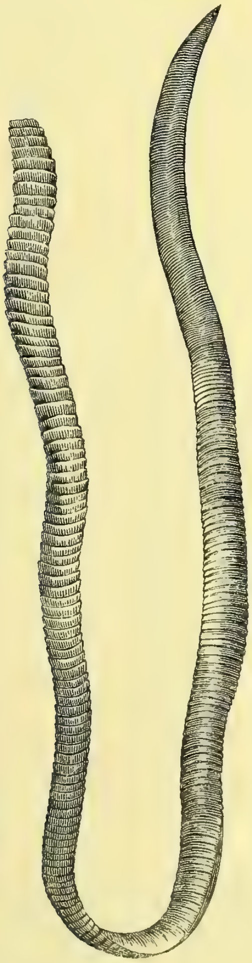

FIG. 66.—Example of *Bothriocephalus cordatus* from the human body. (Natural size.)—Leuckart.

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* The peculiar Danish title *Justizrath,* which I have here rendered "Counsellor," does not imply any legal honour. It is merely equivalent to "Authorized Medical Inspector."

intervention of a long neck. The segments are distinct from the very commencement near the head, and so rapidly do they increase in width that the anterior end of the body becomes lancet-shaped. About fifty joints only are immature; and, in the longest example, (115 centimetres) Leuckart counted a total of 660 joints. It is, however, a smaller species than *B. latus*, and is further distinguished by displaying a greater number of calcareous corpuscles, and, more particularly also, in the "form of the uterine rosette, which is not only smaller and longer, but likewise exhibits a greater number of lateral processes." Leuckart thinks that the *T. vulgaris* of Linneus and Pallas may be identical with this species. To the naked eye (judging from the figures, and from the preparations which Leuckart has kindly contributed to my cabinet,) *B. cordatus*, at first, reminds one of Goeze's thick-set *Tænia pectinata;* but the structure of the latter is very different. Lastly, from the history of the solitary case quoted by Leuckart, the *Bothriocephalus cordatus* does not appear to give rise to very formidable symptoms in the human subject.

CHAPTER X.

NEMATODA.

The Nematoda, or round worms infesting man—General and specific characters of *Ascaris lumbricoides*—Structure and development—Views of Czermak, Eberth, and Schneider—Experiments of Richter, Verloren, Davaine, and the author—Practical considerations—Remarkable cases—Treatment.

I come now to the consideration of the third large group of human helminths, commonly called the round worms, or Nematoda; and, as the ordinal characters are already given in the first part of this volume, I need here only remark upon one or two peculiarities of the group, which I have, hitherto, designedly omitted. Thus, it may be noted, that our knowledge of the life-phases and migrations of the larvæ of these parasites is much more limited than obtains in the case of the Cestoda, although the metamorphoses displayed by the latter are much more complicated. With the exception of *Trichina spiralis*, I am not aware that we have a thorough knowledge of the entire life-history of any of the nematode species which infest the human body; nor, indeed, can I call to mind any round-worm infesting the lower animals, whose life-phases, migrations, and peculiarities of structure, during development, are satisfactorily known. Notwithstanding all this, we are, at length, acquainted with a multitude of highly-important and extremely interesting facts, part of which I hope to enunciate briefly in the following pages, and, in doing so, I shall be necessitated to pass over many of those extremely minute structural details, which are of little practical utility, at the same time that I shall be compelled to cast aside numerous false teachings which have from time to time been handed down to us. In many cases, I shall not even allude to these vague opinions, but take for granted that the more absurd ones are no longer deemed worthy of credit by any persons who are likely to peruse this volume.

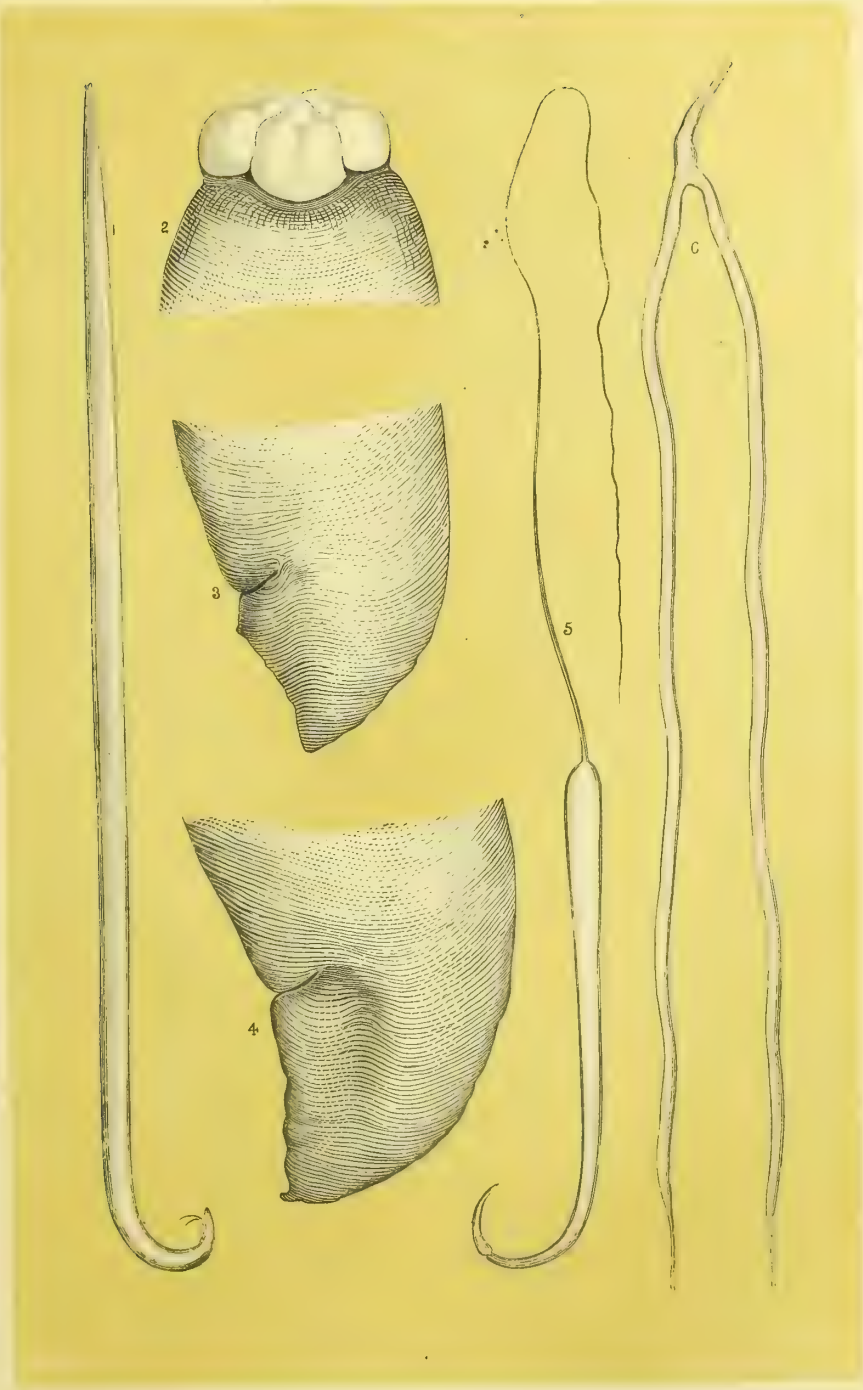
20. ASCARIS LUMBRICOIDES.

A. lumbricoides, Linneus ; Bloch ; Goeze ; etc.
Fusaria lumbricoides, Zeder.
Lumbricus teres hominis, Tyson ; Redi ; Valisneri.
? *Nematoideum hominis* (*ventriculi*), Dégland ; Leveillé ; etc.
? *N. hominis* (*viscerum*), Pruner ; Diesing.
? *Ophiostoma pontierii*, Cloquet ; Delle-Chiaje ; Bremser.

General and Specific Characters.—A nematode helminth resembling the common earth-worm in size and general appearance, the males measuring from four to six inches in length, and the females from ten to fourteen inches; body smooth, fusiform and elastic, marked by numerous fine transverse rings, and attenuated gradually towards either extremity, the anterior terminating in a much produced tri-papillated mouth, the posterior in a bluntly-pointed tail; female much broader than the male, having a diameter of $\frac{1}{4}$ of an inch, and consequently a circumference of $\frac{3}{4}$″; male reproductive organs furnished with a double spiculum or penis, the caudal extremity being otherwise readily distinguished from that of the female by its arcuate form; female reproductive orifice situated towards the lower part of the anterior half of the body, at which point the body frequently bursts after the animal has been placed in water.

This well-known parasite is by some still considered identical with the *Ascaris megalocephala* of the horse, and with the *Ascaris suilla* of the hog; but I have long made up my mind that it is a distinct species, in which view I am anticipated by Dujardin, Moquin-Tandon, Claparède, and many other helminthologists. I need also scarcely add that its earth-worm resemblances are very slight, its affinities and structural peculiarities being altogether different.

The naked-eye descriptive anatomy of *Ascaris lumbricoides* was long ago made out by Cloquet; and full details were given in his well-known "Anatomie des Vers Intestinaux," from which many particulars were subsequently copied by various writers. In the



Ascaris lumbricoides, Linnæus.

T. S. C., delt

London School of Hygiene & Tropical Medicine
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main it may be said that his descriptions were careful and accurate, but some of them have turned out erroneous.

Commencing with the head, I remark, in the first place, that the three prominent oral papillæ are nearly uniform in size, their occasional inequality being accidental. During life they are moveable, and there can be no doubt that their combined action is suctorial. Viewed, from above, with a pocket-lens, the lips present a tripetaloid figure, and, on a more close examination, they exhibit, when separated from each other, a number of minute denticulations at their inner surfaces. The oral aperture, without any other special appendages, leads directly into a strong muscular œsophagus, which in some specimens is fully half an inch in length. A slight constriction separates this part of the canal from the stomach and intestinal tract, these latter divisions of the tube not being recognisable from one another. In fact, different anatomists have variously interpreted the morphology of these parts; but, since many of the nematoda display an organ comparable to a true stomachal cavity, I think it better to regard this thin and spacious portion of the canal as merely representing the intestine. To the naked eye it displays a deep brown colour which is mainly due to the intestinal contents, but as obtains in many allied species, the epithelium and general cell wall are more or less supplied with dark pigment granules. All I need here further say, is that the alimentary canal, in both sexes, is terminated by a cloacal cavity, which opens externally by a transverse slit at a very short distance from the extremity of the tail. In this situation, one not unfrequently finds a number of minute papillæ on the surface of the body, which do not make their appearance elsewhere. And this leads us to examine the skin, which, notwithstanding all that has been said to the contrary, really seems to me to consist of only two well-marked layers, namely, an external chitinous and an internal granular layer. No doubt Czermak and others have been able to split these layers into six or eight different laminæ, but, after all, nothing is gained by so many arbitrary divisions. The chitinous layer is possibly capable of being separated into several distinct lamellæ, like the cleavage layers of a mica sheet, and the circumstance that the layer in question is not originally a distinct cell-membrane, but a chitinous secretion from the primary integument, would favour such a peculiarity. I can only account for Czermak's layers on this supposition. On placing these worms in a solution of carmine, I find all the true cell tissues become coloured, whilst the chitinous covering remains unaffected. As regards the inner or true integumentary layer, this has been supposed to consist of fibres variously blended, by which there have been recognized transverse longitudinal and oblique lines. These linear groupings have generally been held to constitute so many different layers, and certain of them have been regarded as muscular. The oblique markings are generally more distinct in the neighbourhood of the head, and I have seen similar appearances in other nematodes in cases where I could not at all feel satisfied that they represented distinct fibres. It is now, indeed, becoming more and more evident that these markings are illusive, and not to be trusted. They are probably due to the superimposed chitinous layer. I have seen them beautifully distinct in the chitinous capsules of Trichina; Mr. Bastian has seen similar deceptive appearances in Dracunculus; and Mr. Beck has recently offered a highly-satisfactory explanation of these illusive phenomena under other circumstances.* Dr. Eberth in his monograph on the Nematoda has given an admirable figure of these characteristic appearances as they occur in the neighbourhood of the head of *Enoplus megopthalmus*, but he evidently regards them as muscular.

All the tissues of the body appear to be highly elastic and contractile, but the true muscular system consists principally, if not entirely, of four longitudinal bands, two dorsal and two ventral, passing from one end of the body to the other. Histologically, the bundles consist of large, long, fusiform, nucleated cells, which, when cut across transversely, display an appearance of lines running inwards from the granular layer towards the loose parenchyma of the body. This has been well demonstrated by Eberth in the closely-allied, round worm of the horse (Fig. 67). When exposed longitudinally the muscular cells are seen to overlap one another at their extremities, forming a series of dovetail-like arrangements in the mass. In the general cavity of the body we find a quantity of loose parenchymatous cells, which, according to Eberth (in *A. megalocephala*), are connected with and bud out from the inner surface of the great longitudinal bundles. In the living state these loose cells, whatever be their nature, are surrounded by a transparent red-coloured fluid, which is, probably, of a highly-nutritive character.* As regards the nervous system, all I can say from my own examinations simply amount to this: I find the lateral lines characterized by a band of large granular cells, in the centre of which lies a well-marked double-bordered canal, containing fine

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* See a paper in the "Quart. Journ. of Micr. Science" for January, 1864.

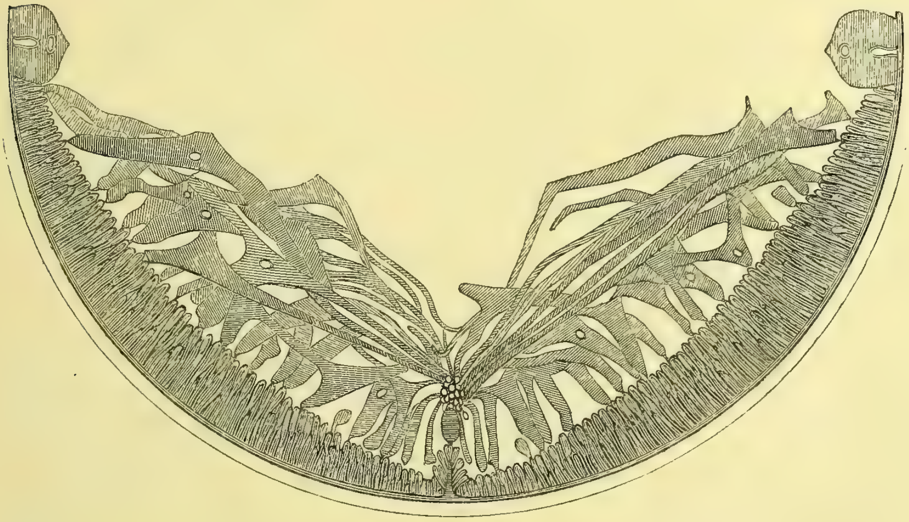

Fig. 67.—Transverse section representing the semi-diameter of the body of *Ascaris megalocephala*, with the viscera removed. Considerably magnified.—Eberth.

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* Dr. Marcet, F.R.S., to whom I have since forwarded as much of the fluid as I could obtain from about seventy of these parasites, informs me that its "composition is similar to that of the juice of flesh in the higher animals;" and he is, therefore, led to infer that the process of assimilation is pretty much the same in both classes.—T. S. C.

granular matter. I cannot call the inner tube a true nervous cord, but, at the same time, I am willing to believe that it represents a rudimentary condition of a true nerve-system. Eberth regards the lateral lines as vascular, but Schneider and others are very positive as to the existence of an internal central as well as an external peripheral nerve-system in these worms. According to Schneider, an abstract of whose views on this point are given by Mr. Busk in the "Microscopical Journal" for 1863, the nervous system in *Ascaris megalocephala* may be described as follows :—"The nerve-collar is placed about one line below the oral orifice. From it six cords are given off in front; four of these (*nervi submediani*) arise nearly in the middle, between the border of one of the lateral intermuscular spaces and the middle line, though rather nearer the lateral space. The roots commence with a broad base, which gradually narrows into the slender cord. Two other nerves (*n. laterales*) lie in the centre of the lateral intermuscular spaces. These nerves are completely imbedded in the substance of the lateral space, and they may, with some pains and trouble, be at once dissected out, or may be seen more readily, but still distinctly, in simple transverse sections. Two strong nervous cords pass backwards; they arise on the ventral surface of the ring, one on either side of the ventral line, towards which they tend in a sort of arch, and are continued a short distance, but they cannot be traced beyond the arched anastomosis of the water-vascular system, which lies a short distance behind the nerve-collar. These are termed *rami communicantes*." Schneider then proceeds to describe numerous ganglion cells in connection with these various true nerve-structures, but it is needless to speak minutely concerning them. If I understand his descriptions rightly, the ordinary lateral vessels are referable, as Eberth and many others still suppose, to the water system, whilst the nervous cords are altogether independent.

I pass on now to the consideration of the reproductive system. As regards the male, the testis consists of a single, slender, and extremely delicate spermatic tube, which is frequently coiled upon itself, and also twisted round the lower part of the intestinal tube. It may, however, be easily unravelled beneath water, and, when fully extended, will reach nearly a yard in length. The internal blind extremity constitutes the narrowest part of the tube, which, after a gradual but inconsiderable increase in width, forms the bulk of the testis proper, and then subsequently widens out to form the *vas deferens*. The latter suddenly terminates at the summit of a somewhat club-shaped pouch, which is usually distended with spermatic particles. Towards the lower part, the pouch itself is also suddenly constricted, and enters a thick muscular sheath, within which the two penes or spicula are lodged during their retraction. Ordinarily, this seminal reservoir is about one inch and a half in length. The spicules are arcuate and rather bluntly pointed, but there is no central groove or orifice at their extremities, as some had led us to believe. As regards the reproductive organs of the female, they consist of the ordinary parts, but the relative development of these is very remarkable. Thus, the uterus and vagina, taken together, are about half an inch in length, but the former divides into two long uterine horns, each of them measuring at least four inches long. At their inner ends they suddenly become narrowed to form two long ovarian tubes which coil upon themselves and around the intestinal canal in a very tortuous manner, terminating finally in extremely narrow cœcal extremities. If either of the tubes be carefully unravelled, it will be found to measure about four feet in length. In full-grown individuals, one constantly finds these canals filled with ova in every conceivable stage of development, from the condition of a simple free nucleated germ, situated at the cœcal extremity, to the finely-granular yelk of the perfect egg, which is just about to emerge by the vaginal outlet. In *Ascaris megalocephala*, I have seen the spermatozoa in immediate contact with the egg-germs, constituting, according to Nelson, the very act of impregnation; but into the details of this process I do not now enter, reserving what I have to say on this point until we are considering the sexual peculiarities of *Ascaris mystax*.

Development and migration.—The precise manner in which the young gain access to the human body is very imperfectly understood. It is well known that quantities of the immature ova are expelled their "host" *per anum*, and I have myself obtained the characteristic eggs from matters ejected by the mouth. Richter's and Davaine's experiments go to prove that after the ova have escaped passively, they complete their development in open waters; and it would also appear that an interval of six months must elapse (after their expulsion) before the yelk-segmentation and consequent embryonic formation can take place. In Richter's experiment none of the embryos had emerged after the eggs had been in the water for a period of eleven months; and in the case of *A. marginata* from the dog, Verloren's previous investigations have shown that the young embryos can retain their vitality for more than a year after their worm-like condition has been attained. According to Davaine ("Comptes Rendus," 1858, p. 1217), the fully-developed embryo is cylindrical, its length being $\frac{1}{100}$th of an inch; the mouth is not furnished with the three characteristic papillæ of the genus, and the tail terminates suddenly in a point.

The experiments of Davaine also show that their development *in ovo* was not facilitated by increase of temperature, neither were the mature eggs affected by several days' immersion in the gastric juice of rabbits and dogs. Further researches, therefore, are required to decide whether the young *Ascarides* eventually gain access to our bodies after the embryos have escaped the eggs and have undergone a series of active wanderings elsewhere, or whether, as seems more probable, they are not directly transferred from river and pond water to the human stomach.

With the view of ascertaining the exact mode in which we obtain the larvæ of these parasites, I have myself conducted a series of experiments, though, at present, the results are rather imperfect. In the case of *Ascaris lumbricoides*, I have only succeeded in procuring the earlier stages of embryonic formation. From *Ascaris marginata* I have reared great numbers of complete embryos, none of which, however, appeared to have escaped from the egg even after a lapse of seven months in water. In the case of *A. megalocephala,* I have reared quantities of free active embryos in a space of less than five months, and I have also succeeded in rearing considerable numbers of similar larvæ from the eggs of *Ascaris osculata,* both in fresh and salt water.* Notwithstanding these limitations, I am confident that the time is not far distant when we shall be able to expose the whole chain of Ascaris-development, which, at present, it must be admitted, is totally disconnected by several missing links.

Practical Considerations.—As a general rule, it may be confidently stated that the presence of one or two Ascarides in the human intestinal canal is not attended with any marked constitutional disturbance; but, every now and then, instances turn up where the reverse of this happens, whilst, in some few cases, their presence is accompanied with the gravest consequences to the unfortunate "bearer." Usually, only a solitary specimen or, at most, from three to six or eight of these worms are found in the same person at one time, but, occasionally, their numbers are considerable. Thus, Küchenmeister alludes to a case where one hundred and three examples were passed by a child, and he also quotes an instance where the intestinal canal of another child harboured between three hundred and four hundred of these worms; but a still more remarkable case is recorded by Gilli (in the "Turin Journal of the Medical Sciences"), where no less than five hundred and ten were passed by a child. But few cases are on record where any considerable number of *Ascarides* have infested the intestinal canal of an adult; but, as the above instances sufficiently testify, large numbers occur in children, in whom, also, they are particularly frequent. The proper habitat of *Ascaris lumbricoides* is the small intestine, but it is not unfrequently found in the stomach, and other parts of the digestive canal. From these localities it sometimes migrates,

* Details respecting the production of these nematode larvæ by experiment will, I trust, hereafter be found in the "Reports of the British Association" for 1864.

not only by the natural passages of the mouth, nostrils, and anus, but also, it would seem, by perforating the intestinal walls. At all events, plenty of cases are on record where these lumbrici, as they are commonly, but erroneously called, have passed partly, or completely, into the abdominal cavity; in other cases they have become lodged within the various abdominal viscera, and even, also, within the pleuræ and pulmonary organs. In several instances they have found their way into the parietes of the abdomen and adjacent superficial parts, in which situations they have given rise to abscesses, and have, therefore, usually been discharged by surgical interference.

As regards the unfavourable symptoms occasionally produced by lumbrici, these, of course, will vary according to the situation they happen to occupy, and they will also be considerably modified by the age and temperament of the person infested. In the stomach and intestines they give rise to colic and shooting pains about the abdomen, followed generally by dyspepsia, nasal itching, nausea, vomiting, and even diarrhœa. Sometimes also there is a considerable amount of cerebral disturbance, attended with general restlessness and convulsive twitchings during sleep. Thus Mr. Woodman has recently recorded in the "Medical Times and Gazette," a serious case of convulsions arising from lumbricoid worms, in which, however, a cure was effected by expulsion of the worms. If I recollect rightly, the same number of the same journal records (anonymously) a case of epilepsy from a similar cause; whilst, an earlier volume of this periodical (1839) mentions an instance where two lumbrici and one tapeworm were associated in the production of similar phenomena. But a much more striking case is also given (anonymously) in the "London Medical Gazette" for 1847 (page 415), where a single lumbricus caused its bearer to be a lunatic for eight years, the patient suffering from cataleptic fits which lasted for two or three weeks at a time. Many other singular cases are quoted in our journals, amongst which I may mention the allusion made to Petrequin, who, in his "Traité Pratique," publishes two cases of amaurosis in young girls from lumbrici.

Amongst fatal cases there is the one by Petrenz, where 200 lumbrici produced acute enteritis, and one by Kell, where the intestine was perforated; also two by Young, where the worms were evacuated by ulceration through the parietes of the abdomen; also Roger's fatal case of intestinal perforation reported in the "Lancet" (1848); also Blair's case in the "Edinburgh Medical Journal" (1861); also Mondière's three cases of perforation cited in the "Medical Chirurgical Review" (1839); also two others by Buchner in the same journal (1851); and one by Luschka, where the worms occupied the cavity of the pleura (1854). In the same periodical (1833) Neilson has recorded a case of discharge of lumbrici from various parts of the body, and much more recently a successful case has been published by Sheppard, who extracted an *Ascaris lumbricoides* from an abdominal abscess ("British Medical Journal," for 1861). Amongst cases producing irritation in the genito-urinary passages, is the one by Dreyfus, recorded in the "London Medical Gazette" (1847), in which a cure was effected by discharge of the worms, and the American case by Buckingham, where the presence of Ascarides gave rise to a formidable erotomania.

In addition to the above I may mention that the third fasciculus of a work illustrating the collection of morbid anatomy in the Army Medical Museum at Chatham, gives a case of lumbrici occupying the biliary ducts and gall bladder; and I also find two more anonymously-recorded cases of lumbrici producing perforation of the small intestine, one of them appearing in the "London Medical Gazette" (1827), and the other in the "Lancet" (1836). But, perhaps, the most curious cases (which illustrate a remarkable peculiarity of habit enjoyed by these parasites) which I have met with are those severally described by Barwell, the Messrs. Prichard, Stockbridge, and Williams. In Barwell's case an Ascaris was expelled a child who had accidentally swallowed a foreign body, or, to speak more precisely, a small toy which formed the brass "eye" of a lady's dress. Through the circular loop of this toy the Ascaris had partially thrust its body, and becoming thus strangulated, it probably perished before it was evacuated. In Prichard's case one or two lumbrici had similarly trapped themselves in the eyes of buttons swallowed by the patient, and one worm, not contented with a single strangulation, had succeeded in passing part of its body through two buttons. This case is given in the "British Medical Journal" (1859), whilst that by Barwell will be found in the "Lancet" for 1857.

In the "Boston Medical and Surgical Journal" for the year 1842, Mr. T. G. Stockbridge gives a similar case, in which he, not inaptly, speaks of these "hooks and eyes" as constituting a new remedy or "worm-trap" for lumbricus; and, singularly enough, a namesake (see W. Stockbridge, in the Bibliography), in the same periodical for the succeeding year, also records another like instance of the "mechanical expulsion of worms" by metallic buttons. Again, in the same serial, a third correspondent, under the initials A. M., speaks of an open-topped thimble as constituting another new "worm-trap," whilst he also gives a case of lumbrici penetrating "metallic suspensor buttons." Lastly, there is the case of Williams, who, at a meeting of the Boston Society for Medical Improvement, exhibited "a lumbricus with a dress-hook attached;" this case being also reported in the Journal above mentioned for the year 1857.

The above, I believe, constitute the majority of the interesting and important cases published in British and American periodical literature; but, whilst I have designedly passed over some of the less noteworthy cases, it is just possible that one or two others of considerable import may have, unfortunately, escaped my research. I could not undertake to refer to all the records where particular remedies have been recommended, though some of these (as, for example, those by Dr. Abbotts Smith, in which he found santonine so valuable) possess much therapeutical interest. In like manner, I have paid little regard to cases where the authors have propounded some palpably untenable theory, such, for example, as that advanced by Rumsey, who, because he found lumbrici occurring in two patients who were troubled with spitting of blood, immediately drew the conclusion that the worms in question were the cause of the hæmoptysis. A reference to his cases will be found in the Bibliography, as well as to each of the other cases above quoted. Many other references are also separately given to various other papers of interest bearing on this subject.

From the observations of Dyer it would seem that lumbrici are extremely common in the Mauritius, but, as happens with most of the other species of Entozoa, they are comparatively rare along the sea border. In all situations where there is an abundant water supply, these parasites are more particularly common; and it is well known that the lowlands of Holland and the lake districts of Sweden are eminently favourable to their existence. All this is explicable enough from what we now know respecting the conditions which are essential for the rearing of the larvæ; but, as I have before observed, it is almost certain that the human body becomes infested, not by the drinking of water which may contain the sexually immature embryos, but by feeding upon the flesh of some quadruped, fish, or fowl which happens to represent the so-called intermediate host.

Treatment.—As regards the treatment of *Ascaris lumbricoides* by the internal administration of medicines, I can only very briefly notice the principal remedies. Foremost among these is santonine, which may be given to children in the form of a simple powder, two or three grains being sprinkled over a slice of bread and butter. It is better still if they can be induced to take it along with castor oil, or, if preferred, a little honey is a very good substitute for the oil. An adult may take as much as five grains twice a day, which may be repeated every second day for a week, but not oftener at the commencement. In all cases the effects of the drug should be carefully watched, as tenesmus, spasms, and even hœmorrhiagic discharges, have been occasioned by its use. The patient should also be warned that the remedy is very apt to pervert the eyesight, so that he sees objects acquiring all sorts of colours, some appearing yellow, others blue, or even green. The urine is also liable to acquire a reddish tinge, a peculiar feature which is very liable to cause alarm. All these strange phenomena, however, pass off without any serious result, those affecting the sight generally disappearing "within a few hours." Küchenmeister thinks that we "should never give more than eight grains in two days, divided into doses of two grains each, twice a day."

According to Dyer, the juice of the unripe fruit of the *Carica papaya*, or papaw-tree, is an extremely valuable remedy. Dr. Pockles of Holzminden recommends the powdered root of the male shield-fern in conjunction with ordinary purgatives; but kamala and kousso, especially the former, are particularly worthy of trial. In the hands of Drs. Mackinnon, Ramskill, and Leared, the red powder of *Rotleria tinctoria* is said to have proved highly efficacious in doses of from one to two drachms every four hours. The tincture of kamala is by some considered preferable. Panna has also been recommended, but its anthelmintic virtues, in lumbricus, are probably inferior even to kousso, which latter is given in the form of powder in half-ounce doses. According to M. Davaine, the so-called varec or Corsican moss, procured from various species of Fucus, is much employed in France, but apparently without any very great success. Aloes, scammony, jalap, and turpentine, and many other drastic purgatives are still occasionally resorted to, but it is very doubtful if any of these drugs have a special action on the lumbrici. When their anthelmintic virtues depend only upon their irritant qualities, it is better, perhaps, to dispense with them altogether. Dr. E. J. Waring, in his brochure previously quoted, speaks very favourably of a variety of remedies little known in this country. *Melanhorrhea usitatissima;* this is the Theeh-tsee (Zet-zi), or black varnish of the Burmese. It is "a most efficacious" lumbricide. The Burmese also employ a fungus or worm-mushroom

(Than-mo), which, according to Dr. Packman, has considerable anthelmintic powers. *Quisqualis Indica* of Linneus; the inhabitants of Java, and the Chinese living at Macao (especially) employ this remedy. By the latter it is termed worm-fruit, Cây-thim. *Vœrnonia anthelmintica* of Willdenow. Dr. Waring says that the seeds of this plant are "held in the highest repute amongst the people of Southern India." It is a small annual, extensively distributed throughout the Peninsula. Amongst the remaining drugs I have only space to give the names of the following, on the authority of Waring:—Oil from the pericarp of *Azardarichta Indica*, root of *Melia Azadarach*, "often confounded" with the above; seeds of *Melia sempervirens;* kernel of the mango (*Mangifer Indica*)*;* hairs of *Mucuna prurita;* bark of *Alstonia scholaris;* juice of *Asclepias curassavica;* the peacock's fan-fern (*Asplenium radiatum*)*;* leaves of *Bridelia spinosa;* oil of *Citrullus colocynthus; Calatropis gigantea; Embelia Ribes; Euphorbia thymifolia; Sphœranthus Indicus; Guilandina Bonducella; Tamarindus Indicus; Indigofera tinctoria; Cadaba Indica; Bryonia callosa* and *B. epigea; Acalypha Indica; Polanisia icosandra; Hugonia mystax; Morinda umbellata; Bauhinia variegata; Agatholes chirayta; Curcuma Zerumbet; Cyperus rotundus; Hoya viridifolia; Dalbergia Sisso; Chenopodium album.*

CHAPTER XI.

ASCARIS MYSTAX.

The author's discovery of the occurrence of *Ascaris mystax* as a human parasite—General and specific characters—Vindication of the accuracy of the statements of Irish naturalists—Cases by Bellingham, Pickells, Scattergood, and Leuckart—Structure and development—General and specific characters of *Trichocephalus dispar*—Organization—Remarks on *Filaria lentis* and *F. trachealis.*

I GLADLY, in the first instance, embrace the opportunity of again attempting to rescue from oblivion a most important contribution to helminthological literature. I here propose to repeat and amplify those proofs which I have previously advanced in the view of establishing a recognition of the fact that the common *Ascaris mystax* of the cat is liable to infest the human body. This position I have worked out independently; but I am none the less happy to learn, from the lips of Professor Leuckart, that another case of this kind occurred in Germany about two years ago. I think I understood him to say that the worms were readily recognized as specimens of *Ascaris mystax.* At all events, from what is stated in the sequel, it is quite evident that all who allowed Bellingham's *Ascaris alata* to be a parasite of some kind or other, regarded it as a new species. Not one single helminthologist ever stated that the parasite in question was really referable to the *Ascaris mystax,* but Dr. J. V. Thomson thought that it *resembled* that species. Many years ago, when I accidentally stumbled upon Pickell's figure, I at once regarded it as a representation of *Ascaris mystax,* and from that time forth I resolved to work out the subject whenever an occasion might offer itself. Thanks to the kindness of Dr. Lankester and Mr. Scattergood, I have since been enabled to carry out my wish, and by the aid of their valuable contribution of specimens I have succeeded in establishing the truth of several facts, which Küchenmeister and others regarded as mere myths, and I have also vindicated the authority and general accuracy of Dr. O'Bryen Bellingham, and other Irish naturalists, whose statements had been, in my opinion, rather unfairly handled by one or two of the leading helminthologists of the day. If my memory does not fail me, the fourth case (to which Leuckart has called my attention) occurred in an adult, in whose digestive tube no less than twelve examples of this worm had taken up their residence. With these few preliminary observations I proceed to give the necessary details as follows :—

21. Ascaris mystax.

A. mystax, Rudolphi ; Bremser ; Dujardin ; etc.
A. felis, Gmelin ; J. V. Thomson ; Pickells ; etc.
A. teres felis, Goeze.
A. cati, Schrank.
A. alata, Bellingham ; Dujardin ; Diesing.
Fusaria mystax, Zeder.

General and Specific Characters.—A moderate-sized nematode helminth, characterized more especially by the presence of conspicuous, alaform appendages, one on either side of the head ; which, however, vary somewhat in their degree of development in different examples of the worm ; the male acquires a length of two inches and a half, whilst that of the female is sometimes a little beyond four inches ; the former also seldom exceeds half a line in breadth, whilst the corresponding measurement of the latter is just double ; the tail of the male is strongly arcuate, whilst the body itself invariably displays a disposition to coil upon itself, the female exhibiting the same tendency in a less marked degree ; the spicules, two in number, acquire a length of about $\frac{1}{20}$ of an inch ; the eggs presenting a longitudinal diameter of $\frac{1}{310}''$.

The late Dr. Bellingham, who was one of the surgeons of St. Vincent's Hospital, Dublin, published in the thirteenth volume of the "Annals of Natural History" an extended catalogue of Irish entozoa ; and in this list he recorded the existence of a new round worm in man, under the title of *Ascaris alata.* This catalogue has been constantly referred to by Dujardin, Diesing, and other sytematic entozoologists, comparatively few of them having, it would seem, had access to Dr. Bellingham's more extended account of this parasite given in the first volume of the " Dublin Medical Press" (No. 7, Feb. 20th, 1839). One is led to make this inference from the doubts which some have cast upon the very existence of the worm; although others, with more candour, suppose the species has merely been mistaken. Thus, Küchenmeister (" Parasiten," s. 464, in Lankester's edit., vol. ii., p. 100) says: " The *Ascaris alata,* found in the small intestine of a man, is probably only a young individual of one of the long-known Nematoda, *if, indeed, it be a worm at all!* (The italics are mine.) This statement is reproduced by Hulme in his English edition of Moquin-Tandon's " Elements of Medical Zoology" (p. 341); and the French author himself evidently shares the doubt of other people. Dujardin (" Helminthes," p. 156) admits the species, as does also Diesing (" Systema Helminthum," p. 175), but the latter unluckily adds the following very significant suggestion:—" An *Ascaris lumbricoides* capitis epidermide emphesematice inflata?" Dr. Leidy of Philadelphia admits *A. alata* among his *Entozoa hominis* without comment (" Smithsonian Contrib." for April, 1853); but Weinland, of Frankfort, in his list, prefixes the species with a note of interrogation, observing, also, that it has been " once" found in Ireland (" Essay on Tapeworms," p. 88). It is quite clear, therefore, that these authors entertain no belief as to *Ascaris mystax* being a human parasite, because those who doubtfully accept Bellingham's *Ascaris alata* do so under the impression that whatever it is, it is quite distinct from the common Ascaris of the cat. The evidence which I shall now adduce is quite conclusive, and ought, once for all, to clear up the mystery.

Dr. Bellingham, in his paper (*loc. cit.*) " On an Undescribed Species of Human Intestinal Worm," remarks that there are three species of ascaris infesting man (*i.e.*, he includes the *A. lumbricoides* and *A. vermicularis*, the latter being now better known as an

Oxyuris); and he proceeds to notice the third form in the following manner:—

"The third species of the genus Ascaris, which occurs in the human intestine, has not hitherto been described (although it would appear to have been already observed in this country); as yet I have met with it only once. It belongs to the third division in Rudolphi's arrangement, and to the subdivision in which the head is winged. From the distinctness of the lateral membranes of the head, I have given it the name of *Ascaris alata*."

Dr. Bellingham states that he possessed two specimens, both females; and having next given a minute description of them, he goes on to remark: "The only instance in which I have as yet met with the *Ascaris alata* was on the occasion of my having prescribed for a child, aged about five years, who exhibited symptoms of worms. I ordered some vermifuge medicine, and desired, in case any worms were voided, that they should be kept. A day or two afterwards the specimens, from which I have taken the above description, were brought to me; they were dead when I received them, and I could not learn that the child ever passed any since." Dr. Bellingham then refers to a previously-published case, where worms "closely resembling" his so-called new species had been "passed by a female residing in the county of Cork," and thereupon concludes his paper with the following statement:—"This species, the *Ascaris alata*, is very distinct from the *Ascaris lumbricoides* of the human subject. In general appearance it is not unlike the *Ascaris mystax*, which inhabits the stomach and small intestines of the cat; it differs, however, in having a greater diameter posteriorly than anteriorly, and in the lateral membranes of the head being broader in the *Ascaris mystax* than they are in the species under consideration. There are some minor points in which they also differ, which will be observed if we contrast the characters of the two species."

So much for Dr. Bellingham's interesting record, which appears to me to be singularly clear and accurate, although, as I shall show in the sequel, he has, after all, only been describing a genuine

Ascaris mystax. In the meanwhile, however, it is necessary to glance at the earlier and still more remarkable communication by Dr. Pickells, where considerable numbers of similar ascarides were obtained from a patient named Mary Riordan, aged twenty-eight years. This case will be found minutely detailed in the fourth and fifth volumes of the "Transactions of the Association of Fellows and Licentiates of the King and Queen's College of Physicians in Ireland." In this instance the first specimen was voided in April, 1822, and on its being submitted to that distinguished naturalist, Dr. J. V. Thomson, of Cork, that gentleman writes to Dr. Pickells as follows :—"The Ascaris resembles most that which is so common an inhabitant of the stomach of a cat (*Ascaris felis*), but is rather longer in proportion to its thickness." After an interval of one year and ten months (Feb., 1824), we are told that several were passed at one time; then, again (Nov., 1825), eleven more, and subsequently (March, 1826), there was another addition of nine, which were thrown up alive. Taken altogether, Dr. Pickells had "seen about fifty of various sizes." These were generally evacuated alive, and, in a majority of instances, without medicine. To use the author's own words, "they came away usually in groups of six or more. I have sometimes," he adds, "found a whole group knit together by the extremities. The common lumbricus (*Ascaris lumbricoides*) was also eliminated in some instances; one measured upwards of a foot."

The mention of the presence of *Ascaris lumbricoides* is particularly important in this case, because some have supposed that Mary Riordan was attempting to impose upon her medical attendants. The case, indeed, is one of singular interest; for this woman not only passed the before-mentioned nematodes, but also an astonishing number of the larvæ of *Blaps mortisaga*, a coleopterous insect "which inhabits such situations as churchyards." This person had, from superstitious motives, long practised the disgusting habit of drinking water mixed with clay taken from the grave of a clergyman or priest, under the impression that she would thus free herself from "both disease and sin." I have mentioned this, not with the view of now discussing the true and false instances where insect larvæ have been obtained from the human body, but for the purpose of directing attention to the possible or probable sources whence the larvæ of *Ascaris mystax* may have been derived, and, in the sequel, I think its importance will be made manifest.

The foregoing communications by Drs. Bellingham and Pickells are, fortunately, accompanied by a few drawings, exact outline copies of which I have here reproduced in order that they may be compared with my original figures, subsequently given. Some time ago, when engaged in preparing the paper "On Human Entozoa," which was read at the last meeting of the British Association at Cambridge, I took occasion to work out this vexed question as to the genuineness of Bellingham's *Ascaris alata;* and I must say that whatever doubts I had previously entertained regarding his two nematodes, they were at once dissipated on viewing the figures given by Dr. Pickells in the work above cited (Vol. iv., Plate III., Figs. 6, 7, 8).

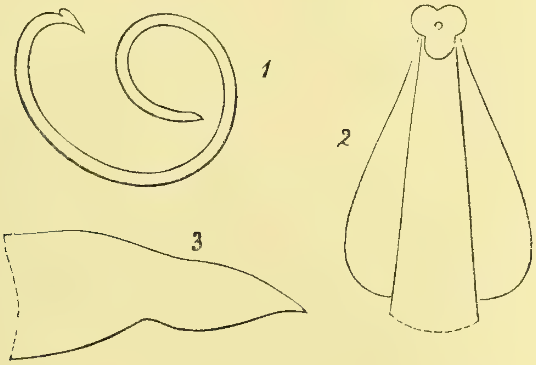

FIG. 68.—1. Outline of an "*Ascaris* ejected by vomiting;" natural size. This was probably a female. 2. Head of the same, magnified, showing the trilobate mouth and alæ. 3. Lateral view of the tail of the same, magnified, showing the anal cleft.—Pickells.

Having thus, by an examination of these figures and writings, and from my familiarity with specimens of *Ascaris mystax* obtained from cats, arrived at the conclusion that Bellingham's *Ascaris alata* was neither more nor less than *A. mystax*, it is a matter of great satisfaction to myself that I am *now enabled to bring forward a third instance of the occurrence of Ascaris mystax in the human body*, and that, too, under the following clearly-defined circumstances :—

About the middle of November, 1862, Dr. Edwin Lankester, F.R.S., Coroner for Central Middlesex, received from Mr. Scattergood, M.R.C.S., of Leeds, a specimen of a nematode worm (one out of eight examples), accompanied by a note explaining the source from which it had been derived. On the evening of the 21st of November, Dr. Lankester called my attention to this parasite, and, in a most disinterested manner, permitted me to examine it at leisure, with the view of making any further use of it which I might think advisable. On seeing the worm, I did not doubt, for a moment, that we had stumbled upon a genuine *Ascaris mystax*, and therefore, at once, putting myself in communication with Mr. Scattergood, the latter gentleman, on the 22nd of November, obligingly favoured me with the following important particulars :—

"I have great pleasure in sending you, herewith, three more of the entozoon, and, should any others be found, will gladly send you the recent specimens. The eight entozoa, of which you now have four, were passed early in this month, after a few days of diarrhœa and fretfulness, by a child *thirteen months* old, the son of a respectable merchant in this town. I have made careful inquiries respecting the child's food, etc., and have every reason to believe that the following account is correct. The child, though suckled to the age of seven months, had also been fed with milk and water sweetened with loaf sugar. At the age of eleven months, flour, oatmeal, or 'rusk' was added to this, and subsequently a little bread, farinaceous puddings, potato with gravy, soup, and broth. The water used was that supplied from the Leeds waterworks. It was not filtered, but was always boiled before adding it to the milk. The child very rarely drank water by itself; if he ever did, it was filtered water, as used by the rest of the family. During the last two months or more he occasionally sucked a piece of meat, but it was always taken from the cooked joint eaten by the family; he never had raw meat or uncooked ham. During the last two or three months, or more, the nurse had frequently given him a *piece of celery* to chew; of this he was very fond. He had not been from home for some months. . . . . The child's general health had been good; no worms had been seen in the evacuations previously. After the worms were shown to me, I gave a dose of castor oil, and examined the fæces. I found in them several white filaments, which proved to be bundles of vegetable vascular tissue and spiral vessels—evidently from the stalks of celery. After this the diarrhœa ceased, and though the evacuations have been frequently examined since, no other entozoa have been found."

Nothing could be more explicit or better to the point than this information; but having observed the extreme incredulity of foreign parasitologists (especially Dr. Küchenmeister) in regard to other equally well-ascertained facts, I resolved, at the risk of proving troublesome, to make certainty doubly certain, by suggesting to Mr. Scattergood the possibility of deception having been practised upon him. His reply to my second letter is equally satisfactory, and runs as follows:—

"The possibility of fraud or of mistake was not overlooked in my inquiries. The proof of the presence of the parasites in the child's evacuations depends, not on the evidence of the nurse, but of the mother, who is an intelligent person, and the daughter of a medical man. . . . . The celery was probably the means of introducing the entozoa. The market gardens about large towns are often watered from ponds or streams which may contain all manner of abomination."

The opinion here enunciated by Mr. Scattergood is one with which I am fully disposed to agree, seeing that it accords in the main with the conclusions deducible from numerous recent experiments, made with the view of ascertaining the development and migrations of the Nematoda. Thus, for example (as I have elsewhere remarked), in the case of the closely allied *Ascaris lumbricoides,* the independent investigations of Richter and Davaine, with fresh eggs, "only go to prove that after the ova have escaped passively, *per vias naturales,* they complete their embryonic development whilst free in open waters. In Richter's experiment none of the embryos had emerged from the eggs, although they had been in water eleven months; whilst the previous investigations of Verloren with the eggs of *Ascaris marginata* of the dog, showed that the young embryos can retain their vitality for more than a year after their worm-like condition has been attained." After a similar manner the escaped ova of *Trichocephalus dispar* require a period of six months after their expulsion before the embryonic condition is fully attained; but in the case of *Ascaris osculata* infesting the seal, my own recent experiments go to prove that the embryonic development may be completed a few days after the eggs have escaped into open waters. On the whole, therefore, it has become evident that some round worms pass through their early development much quicker than others; and in the case of those which do not produce their young viviparously, it is necessary that the ova become immersed in water for a longer or shorter interval; and it is chiefly through this aqueous medium that they gain access to our bodies. Before very long, we hope to be able to give a complete record of the history of the development of each individual species which infests the human body; but those who have not practically attended to these inquiries can scarcely be aware of the numerous difficulties which beset our investigations in this direction.

Leaving now, therefore, the question as to the mode of immigration to the human host, it remains for me to direct more particular attention to the specific characters of *Ascaris mystax.* The accompanying figures, with their explanatory references below, will indicate the leading points to be observed; but I may especially remark upon the circumstance, that the so-called "wings" of the head vary considerably in different individuals. This occurs

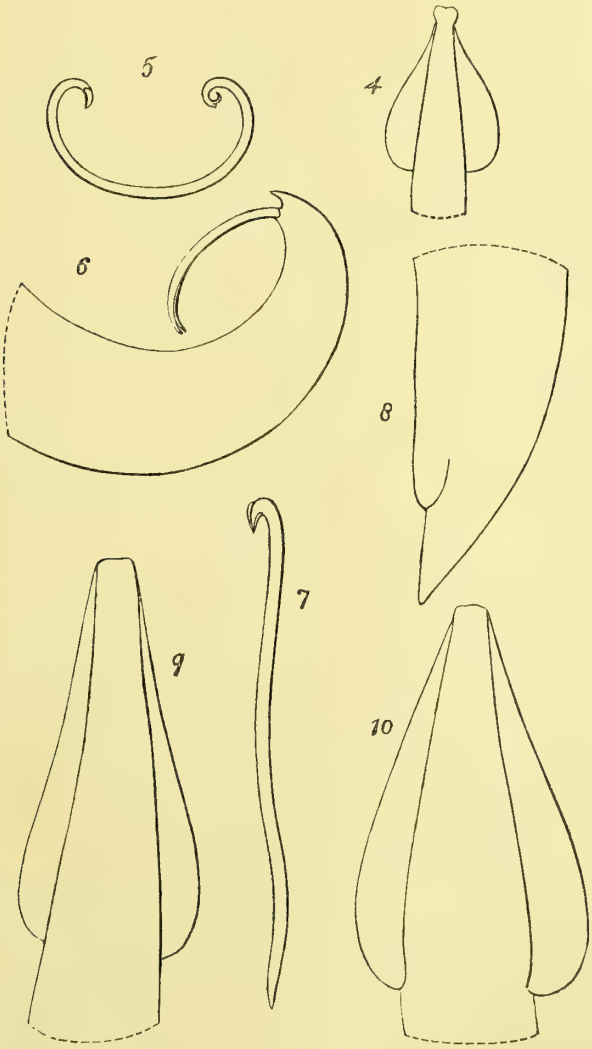

Fig. 69.—4. Outline of the head of the so-called *Ascaris alata;* magnified.—Bellingham. 5. Male *Ascaris mystax,* naturally coiled upon itself; Mr. Scattergood's case. 6. Tail of the same, showing its arcuate outline and double spiculum; magnified 30 diameters. 7. Female *Ascaris mystax* of the natural size; Mr. Scattergood's case. 8. Tail of the same, showing the anal cleft and straight ventral border; × 30 diameters. 9. Head of a female *Ascaris mystax* with inconspicuous alæ; from the same case; viewed from behind; × 30 diam. 10. Head of the *Ascaris* outlined at Fig. 7, in which the alæ are broader; magnified 30 diameters; viewed from behind.—Original.

without relation to sex, the *alæ* being strongly pronounced and broad in some, whilst in others they are attenuated and inconspicuous. The stress, therefore, which Bellingham and others lay upon these appendages, in view of determining specific differentiations, is utterly valueless, at least, in so far as mere size and conspicuity are concerned; but when variations of outline—constant, within certain limits—are found associated with other peculiarities, either of structure or habit, then the question of specificity is fairly raised. In the present case I entertain no shadow of doubt as to the identity of Bellingham's *Ascaris alata* with Dr. Pickell's nematode, "similar to the supposed *Ascaris felis*," and with the round-worms contributed by Mr. Scattergood. They are all examples of the ordinary *Ascaris mystax* of the cat, a species with which helminthologists are perfectly familiar.

In executing the magnified views which I have given at page 325 (6, 8, 9, 10), I was careful to employ a camera to ensure accuracy; but this plan was evidently not pursued in the amplified representations shown by Drs. Bellingham and Pickells. I mention this, not to cast a slur upon their extremely interesting communications, but to caution systematists against relying upon comparative differences of outline, when these would not have been so strongly indicated if the same method had been pursued by these authors in delineating the ascarides which came under their observation. On this subject I might say much more, but I have now fairly proved that the *Ascaris mystax* should henceforth be numbered among the human Entozoa.*

Structure and Development.—Into the anatomy of this worm it is quite unnecessary to enter, as, in the main, it closely corresponds with that of the larger species already described; but as we have already touched upon certain facts in connection with the embryos and their probable mode of introduction into the human body, it will here be desirable to notice very briefly the leading phenomena associated with the development of the eggs.

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* The foregoing remarks form the basis of a communication first published in the pages of the "Lancet" for January 10, 1863, and subsequently reprinted in the "Dublin Medical Press," for February of the same year. I had also previously advocated similar views in my paper communicated to the British Association in September 1862, and also, afterwards, at the Zoological Society. See "Proceedings of Zoological Society" for November 25, 1862.—T. S. C.

If a full-grown female *Ascaris mystax* be carefully slit open, and the exposed reproductive organs be then removed and spread out, the latter will be found to consist, first, of a utero-vaginal canal $1\frac{1}{2}''$ in length; secondly, of two uterine horns, each $\frac{1}{2}$ an inch in length; and thirdly, of two remarkably long and delicate ovarian tubes, which terminate in very fine cœcal extremities. Within these blind ends, the egg-germs first make their appearance in the form of minute free nuclei, and nucleated cellules, which on their passage downwards become surrounded by granules to form the future yelk. The first part of the tube may therefore be looked upon as the strictly ovarian portion (germstock), whilst the succeeding division may be regarded as the vitelligene organ (yelk-stock); these are followed by the oviducts, which open into the

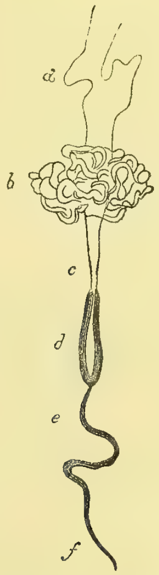


FIG. 70.—Dissection of the female reproductive organs of *Ascaris mystax*; *a*, the fine cœcal ends of the ovarian tubes; *b*, vitelligene folds; *c*, oviduct; *d*, horns of the double uterus; *e*, *f*, utero-vaginal passage.—Original.

uterine horns. During the passage of the germs down the vitelligene portion, the yelk granules have surrounded the nucleated germ-vesicles so as to be capable of separation into distinct granular masses; and, still lower down, they assume, first, a polyhedral or flattened sub-triangular figure, and then, subsequently, a more or less clavate outline, the narrow ends, or *pedicles*, of which converge, as it were, towards a central granular longitudinal axis, termed the *rachis*. At a later stage within the upper part of the oviducal portion of the reproductive tube, the unimpregnated ova separate from the central granular rachis, and shortly afterwards they are, in this situation, brought in contact with the thimble-shaped spermatozoa of the male. According to Nelson the male elements enter the ovum at any point, because, in his opinion, in which Thomson also shares, the granular mass, though well defined, is not, at this period, surrounded by a true yelk-membrane; but Meissner, on the other hand, affirms that the ova are enveloped by a delicate membrane, and that the spermatozoa enter at the point where the pedicle separated from the central rachis. This opening he terms the micropyle. At all events, the union of these different sexual elements constitutes the very act of impregnation. Similar phenomena have been witnessed by myself in

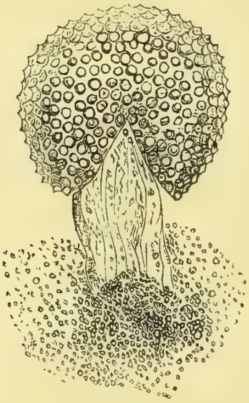
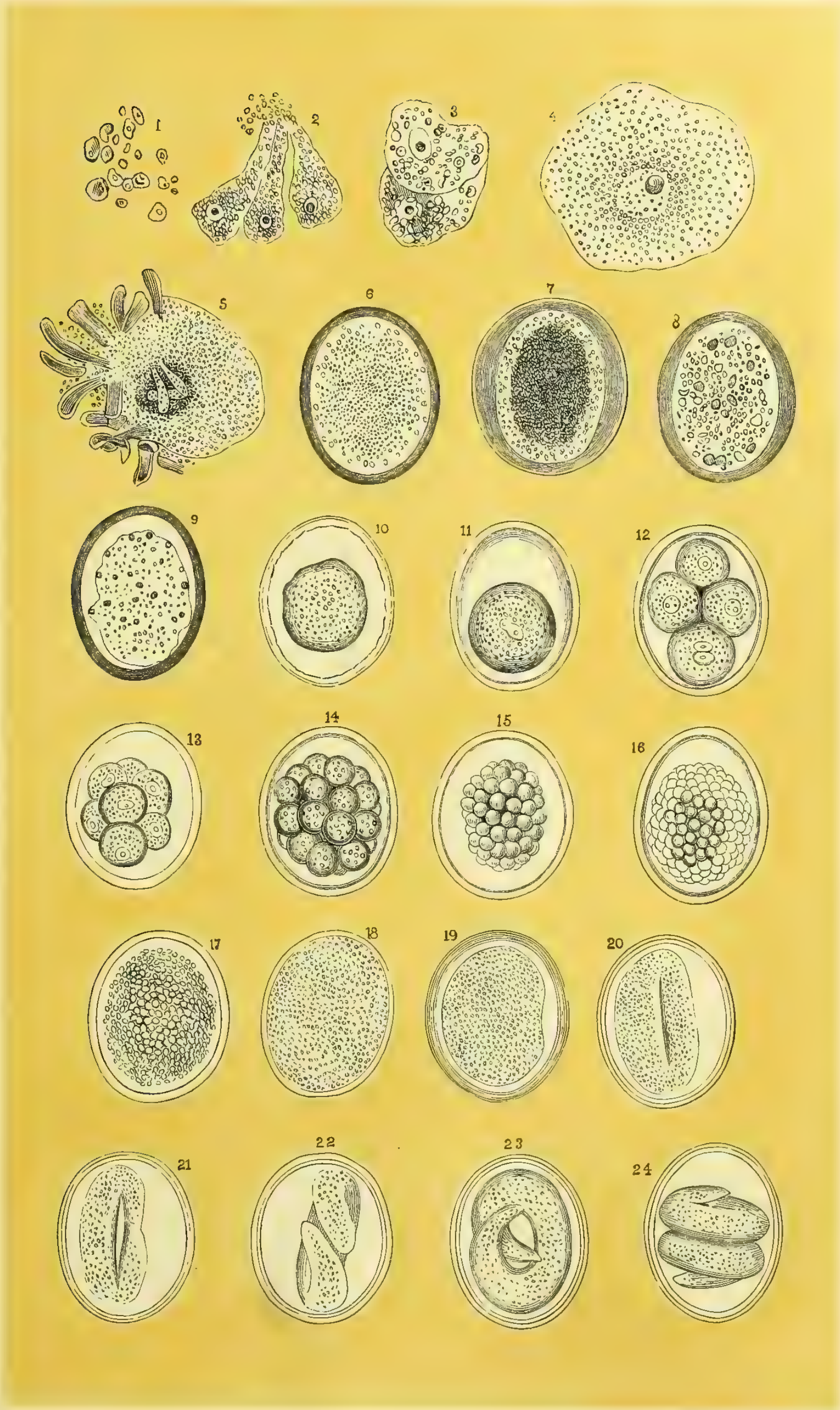


Fig. 71.—Ruptured egg of *Ascaris mystax*, displaying the sculptured chorion, delicate vitelline membrane, and granular yelk; highly magnified.—Claparède.



Egg-germs, eggs and embryos of Ascaris mystax, Rudolphi.

After Nelson.

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Ascaris megalocephala, but I could not speak confidently as to the precise manner in which the spermatozoa were brought in contact with the granular yelk. The union of the sexual elements is quickly followed by a condensation of the yelk granules and the disappearance of the hitherto centrally placed germinal vesicle. The ovum next assumes a distinctly oval form, the true yelk membrane and the external chorion, or shell membrane, now becoming more and more distinct, until the latter acquires a regularly tuberculated surface, and the egg finally assumes its characteristic figure. Co-ordinating with these changes the granular yelk is seen to develop itself into a large embryonic cell, which, after a while, divides and subdivides by the well-known process of yelk-segmentation, until, at length, we have the worm-like embryo developed and coiled upon itself in various ways. In *Ascaris mystax* the young does not make its escape from the shell until after the escape of the egg from the body of the parent; but, I need hardly add, there are many viviparous nematodes in the oviducts of which one may see the young moving about freely, during life. As examples, I may mention *Dracunculus medinensis*, *Strongylus paradoxus*, and *Cucullanus elegans*.

22. TRICHOCEPHALUS DISPAR.

T. dispar, Rudolphi; Bradley; Bremser; etc.
T. hominis, Goeze; Schrank; Gmelin; etc.
T. simiæ patas, Treutler.
T. lemuris, Rudolphi.
T. palæformis, Rudolphi; Dujardin.
Trichuris, Buttner and Rœderer; Wagler; Bloch.
Ascaris trichiura, Linneus; Müller; Werner.

General and Specific Characters.—A small nematode helminth, the male measuring one inch and a half in length, and the female fully two inches; characterized especially by an extremely long filiform neck, occupying about two-thirds of the entire length of the body; surface of the skin smooth to the naked eye, but, when highly magnified, seen to be furnished on one side with a longitudinal band of minute wart-like papillæ, at the borders of which the ordinary circular striæ of the integument terminate; tail of the male curved, and emitting at the extremity a short, tubular penis-sheath, armed with minute retroverted spines; tail of the female straight and bluntly pointed; eggs $\frac{1}{480}''$ to $\frac{1}{447}''$ in their longest diameter.

Few of the entozoa have excited more interest than this species, partly owing to the angry discussion which its discovery inaugurated, and partly on account of its singular and elegant whip-like appearance. The original name of *Trichuris*, given to it by Buttner, could not, of course, be allowed to stand when it became evident that the so-called tail was in reality the head and neck. The *Trichocephalus* is generally thought to be scarce in England—a persuasion which has possibly arisen from the negligence of pathologists, whose arduous duties, connected with the superintendence of *post-mortem* examinations, have perhaps left them little time for these inquiries. On the other side of the Channel, this worm is so abundant in some localities that M. Davaine calculates that not less than one-half of the inhabitants of Paris are infested by it. According to Dujardin, it can be scarcely less abundant in Northern France, for M. Duval, the distinguished director of the Rennes School of Medicine, supplied that helminthologist with numerous specimens, apparently, on many different occasions. Of late, I have gradually become more persuaded that this parasite is really rather a rarity this side the Channel, especially since my friend Mr. Noel has assiduously striven to detect the presence of these worms, in the *post-mortem* room of the Middlesex Hospital, for nearly a year past without any other than a negative result. Until lately, the only specimens, five or six in number, which I have had an opportunity of examining in the fresh state, I owed to the liberality of Dr. Haldane, who found a considerable number, in one case, whilst acting as pathologist at the Royal Infirmary of Edinburgh.*

Structure and Development.—The general organization of

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* Since the above was written, and very recently (June, 1864), Mr. Noel has succeeded in finding *Trichocephalus dispar* in two separate subjects.—T. S. C.

Trichocephalus has been well investigated, more particularly by Mayer, Siebold, Dujardin, Blanchard, Küchenmeister, and Eberth; but (as I have shown in my third memoir on "Entozoa," published in the "Linnean Society's Transactions") the statement of Küchenmeister, that there are no external appendages in the female of *Trichocephalus* comparable to those known to exist in the allied *Trichosomata*, is incorrect. In connection with these organs I have also endeavoured to throw light upon the conflicting statements of Mayer and Eberth, and I have demonstrated, more fully, the very marked differences existing between the males of *Trichocephalus affinis* and *T. dispar.* The presence of the last-named species in the human body is fortunately attended with very little inconvenience; but its development and mode of gaining access to the host has, nevertheless, been recently made the subject of diligent inquiry. Leuckart's, and especially also Virchow's, researches have entirely disproved Küchenmeister's notion that *Trichinæ* are the young of *Trichocephalus;* and the experiments of Davaine render it probable that the young get into the human body in a manner very similar to those of *Ascaris lumbricoides.* The latter authority finds that the eggs undergo no development whilst yet lodged within the host's intestine, and they are expelled *per anum* in the immature condition in which they make their escape from the body of the parent worm. It further appears that, after their expulsion, a period of six months must elapse before the embryonic formation commences—an interesting circumstance, and one which satisfactorily explains why it was that my own feeding-experiments (on a chicken and rabbit) with the fresh eggs of *Trichocephalus affinis* gave only negative results. According to Davaine, the fully developed embryo measures $\frac{1}{333}$ of an inch in length, and, inasmuch as it tapers gradually from behind forwards, to a certain extent, resembles the parent.

For other anatomical details and illustrations of *Trichocephalus* I must refer the reader to the fifth chapter of the first part of this work.

? 23. Filaria lentis.

F. lentis, Diesing; Weinland; Gervais and Van Beneden.
F. oculi-humani, Nordmann; Gescheidt; Ammon; etc.
F. oculi, Owen; Moquin-Tandon.

As Küchenmeister suggests, this worm may possibly turn out to be identical with the *Filaria lacrymalis* (Gurlt), a viviparous species infesting the eye of the horse. It was first discovered by Nordmann (1831) in a case of lenticular cataract under the care of Von Gräfe, and subsequently found by Jüngken under similar circumstances. M. Davaine also mentions another comparatively recent case of Filaria in the anterior chamber of the eye, but full particulars of it do not appear to have ever been published. The case, previously cited, is by Sichel ("Iconographie ophthalmologique," p. 707), from whom we gather that the specimen was brought forward by Quadri of Naples, the latter authority exhibiting the parasite *in sitû* at a meeting of the Ophthalmological Congress held at Brussels. Then, again, there is the case observed by Gescheidt, in which Von Ammon operated for cataract. In this instance, there were three Filariæ, two of which measured about $\frac{1}{6}$ of an inch apiece, whilst the third was only about the $\frac{1}{15}''$ in length. The two former were regarded as females, but it is more than doubtful if any of them were sexually mature. The same, probably, may be said of all the others hitherto mentioned, and this being the case, it becomes impossible to say how many distinct species of Entozoa these several examples of so-called Filariæ may happen to represent. To my mind, all of them are embryonic nematodes which have accidentally, or otherwise, selected the human body as their intermediary host. As I said before, we have no certain evidence that any of these worms had developed sexual organs in their interior. It is true that the reproductive organs were described in two of the worms observed by Gescheidt; but after a due consideration of all the facts which have been advanced, I agree with Küchenmeister in concluding that the nematodes, in question, were quite immature.

? 24. Filaria trachealis.

Nematoideum tracheale, Rainey and Bristowe.

In this place, it seems to me appropriate to notice briefly the filaria-like nematode described by Bristowe and Rainey in the "Pathological Society's Transactions" for 1855. This minute parasite evidently represents only a very juvenile stage of the larval development of some particular species of round-worm. To what specific form it may belong we cannot state with any degree of certainty; but on comparing its characters with those displayed by the young of *Ascaris megalocephala* of the horse, one might not be far wrong in conjecturing that it may be referable either to this species or, possibly, to the closely-allied *Ascaris suilla* of the hog. From the record above cited, it appears that Rainey discovered a considerable number of these worms in the trachea and larynx of a person who died from a disease affecting the lower extremities. As the parasites only measured about the $\frac{1}{50}$ of an inch each, it is scarcely probable that they had occasioned the otherwise unfortunate bearer any appreciable inconvenience.

Nematoideum not being a recognized genus, I have provisionally placed this larval round-worm among the Filariæ.

CHAPTER XII.

TRICHINA SPIRALIS.

General and specific characters of *Trichina spiralis*—Historical notice—Our knowledge of the structure, migrations, and development of Trichina, as gathered from the investigations of Owen, Bristowe and Rainey, Virchow, Leuckart, and Davaine—Medical importance of the subject—The flesh-worm epidemic, or so-called Trichiniasis—Cause of its prevalence in particular localities—Gamgee's practical observations—Value of the experimental method of research.

At the close of the last chapter, under two separate headings, I described certain larval nematodes which, after all, may possibly be referable, not to two, but to three or even more species of worm whose appropriate adult forms remain, at present, only a matter of conjecture ; but, be that as it may, I come now to speak of a parasite whose history, structure, development, migrations, embryonic and adult conditions are all thoroughly well known. I need hardly add, also, that the worm in question possesses an unusual amount of interest, alike for the professional reader and the lover of natural history science, especially if they be inclined to view the animal in its various economical bearings. With the aid of Leuckart's exhaustive memoir* it would not be difficult, indeed, to devote a chapter or two to the experimental details on which our intimate knowledge of the habits of the *Trichina spiralis* depends; but besides *his* researches we have the earlier though less comprehensive investigations of Virchow and Herbst, and the later, but equally interesting and independent, observations of Davaine.

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* "Untersuchungen über *Trichina spiralis* ; zugleich ein beitrag zur kenntniss der Wurmkrankheiten." 1860.

25. TRICHINA SPIRALIS.

T. spiralis, Owen; Farre; Henle; etc.
Pseudalius Trichina, Davaine.

General and Specific Characters.—An extremely minute nematode helminth, the male in its fully developed and sexually-mature condition measuring only the $\frac{1}{18}$ of an inch, whilst the perfectly developed female reaches a length of about $\frac{1}{8}''$; body rounded and filiform; usually slightly bent upon itself, rather thicker behind than in front, especially in the males; head narrow, finely pointed, unarmed, with a simple, central, minute oral aperture; posterior extremity of the male furnished with a bilobed caudal appendage, the cloacal or anal aperture being situated between these divergent appendages; penis consisting of a single spicule, cleft above, so as to assume a V-shaped outline; female stouter than the male, bluntly rounded posteriorly, with the genital outlet placed far forward, at about the end of the first fifth of the long diameter of the body; eggs measuring $\frac{1}{1270}''$ from pole to pole; mode of reproduction viviparous.

So familiar is the English reader with the circumstances attending the early history and discovery of this parasite, that it is unnecessary to do more than glance at this part of our subject. The Trichinæ originally discovered by Owen in a portion of human muscle transmitted to him by Mr. Wormald of St. Bartholomew's Hospital, we now know to represent merely the larval condition of the adult nematode worm whose characters are briefly given above. It detracts nothing from the merit of Owen, that these little worms have turned out to be only the wandering brood of a more highly organized nematode; but, independently, the discovery gathers additional importance from the fact that, prior to the publication of Owen's observations, the calcareous cysts enveloping the Trichinæ had been noticed by several observers on the Continent, who, not having examined them with sufficient care, appear to have jumped to the conclusion that they ought to be regarded merely as evidences of muscular degeneration. To my mind, this discovery is one of the happiest to which the English helminthologists can point, for, apart from its intrinsic interest, it has led to the most important practical results.

It is not, indeed, a little curious and instructive to note, in passing, one or two of the observations made by Owen in his article Entozoa in "Todd's Cyclopedia" (vol. ii., p. 115). "The cases," he says, "which had occurred before the publication of the first description of this Entozoon led me to conceive that although the species was of so minute a size, yet the number of individuals infesting the body was so immense, and their distribution through the muscular system so extensive, that they might occasion debility from the quantity of nutriment required for their support." Now, the conception here enunciated turns out to be almost absolutely correct, but Owen was himself subsequently led to abandon this view because "no painful or inconvenient symptoms were present in any of the cases" such as might have led "the medical attendents to suspect the condition of the muscular system, which dissection afterwards disclosed, and it is probable," he added, "that in all cases the patient himself will be unconscious of the presence of the microscopic parasites which are enjoying their vitality at his expense." Owen then quotes one of the interesting cases subsequently recorded by Curling in the "Medical Gazette" (1836), in which evidence was given in favour of the possibility of a person enjoying "robust health," notwithstanding the fact of his body being extensively invaded by these little parasites. In the sequel, however, I shall show that the Trichinæ are capable not only of producing pain and general prostration of the vital powers, but even, in many cases, death. At the time at which I am now writing, the Hanoverian and German daily journals teem with records of the Trichina-epidemic, which here and there carries off many victims.

In the meanwhile, however, not to depart from my ordinary mode of dealing with this subject, I must say a few words respecting the structure, and many more concerning the development of the Trichina. In doing this I am enabled to follow out, independently, a great many of those facts which have been observed by others, especially since I had the good fortune to obtain numerous fresh specimens of muscle-Trichinæ during my residence in Edinburgh, and more particularly, also, since Leuckart has recently supplied me with abundant examples both of the sexually-mature and immature worm, derived from various experimental animals. In regard, also, to the numerous excellent memoirs on the larvæ which have from time to time appeared, it is impossible for me to do more than state the general results obtained by their respective authors. Besides Owen's original writings, helminthology must acknowledge its indebtedness to Wood, Farre, Paget, Knox, Harrison, Hodgkin, Gairdner, Sanders, Kirk, Turner, Parkes, Frank, and Bowditch. Especially, also, may I be permitted to particularize the beautifully illustrated memoir of Messrs. Bristowe and Rainey in the "Pathological Society's Transactions" for 1854, the *résumé* given by Aitken, and, more particularly, the recently published brochure by Dr. Althaus.* And, finally, as regards foreign writers, I need only enumerate Henle, Diffenbach, Fricke, Oppenheim, Leblond, Siebold, Kobelt, Nordmann, Valentine, Bischoff, Diesing, Dujardin, Münster, Svitzer, Luschka, Küchenmeister, Herbst, Waldeck, Zenker, Weinland, Van Beneden, Moquin-Tandon, Kühne, Boehler, Koenigsdoeffer, Freytag, Friedreich, Knoch, Virchow, Leuckart, Davaine, and Rupprecht Fiedler.†

The young Trichinæ, as ordinarily observed in the human muscle, present the form of spirally-coiled worms in the interior of small, globular, oval, or lemon-shaped cysts, which latter appear as minute specks scarcely visible to the naked eye. These specks, as we have already stated, sometimes resemble little particles of lime, and, in point of fact, are more or less calcareous externally, according to the degree of degeneration which their walls have undergone. In shape and general aspect they are not altogether unlike certain eggs, such as those of *Trichocephalus* and *Trichosoma;* but their size, alone, would be sufficient to distinguish them, since they measure on an average $\frac{1}{78}''$ in length, and $\frac{1}{130}''$ in breadth. Into the minute structure of their walls it is needless to enter, but

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* On poisoning by diseased pork; being an essay on Trichinosis, or flesh-worm disease; its prevention and cure. By Julius Althaus, M.D., M.R.C.P., Lond., Physician to the Royal Infirmary for Diseases of the Chest. London: 1864.

† See Virchow's Archiv; XXVI., s. 573.

I may remark, also, that the presence of these organized capsules is by no means so essential as some have supposed, if, indeed, they be at all requisite. As Leuckart has shown, they are rather to be regarded as abnormal formations; for, in many cases where

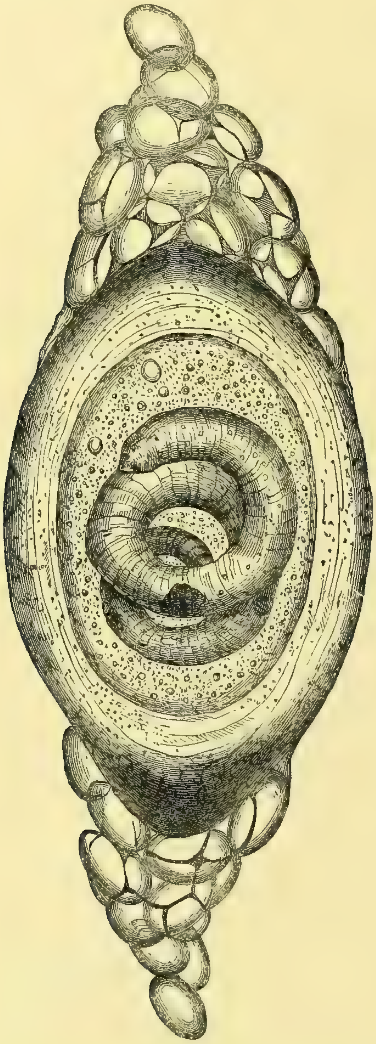

Fig. 72.—Highly magnified representation of *Trichina*, spirally coiled within its cyst.—Bristowe and Rainey.

hundreds of Trichinæ co-exist in the muscles, these cysts may be altogether wanting. The larval Trichinæ themselves measure the $\frac{1}{25}''$ in length, with a transversal diameter of about $\frac{1}{630}''$ ($\frac{1}{30}''$ by $\frac{1}{700}''$ according to Owen); and, without attempting a minute description of their organization, it may be stated that not only do they exhibit a well-marked digestive apparatus in their interior, but, also, distinct evidences of the presence of reproductive organs, which are often, indeed, sufficiently developed to enable us to determine the sexes. As regards the number of larval Trichinæ in any one "bearer" at a time, this, of course, must be extremely variable, but there can be no doubt that it may amount to at least twenty millions. In one of the cats which Leuckart successfully experimented on, he estimated a single ounce of its muscle-flesh to harbour no less than three hundred and twenty-five thousand Trichinæ. If all the voluntary muscles of the human body were infested to the extent of only fifty thousand Trichinæ to the ounce, that would give us a total of upwards of thirty millions of worms in the flesh of a single person.*

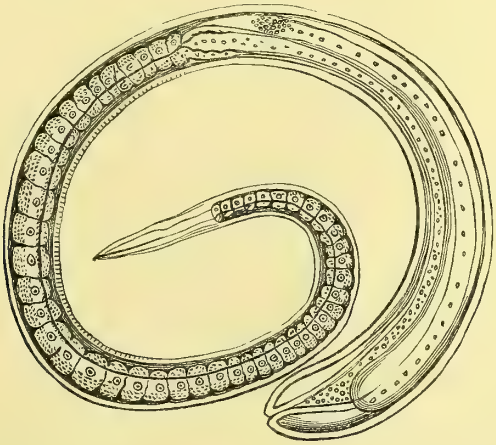

FIG. 73.—Sexually mature female *Trichina spiralis*, from muscle. (Highly magnified.)—Leuckart.

Respecting the sexually-mature or adult Trichina, it is important to observe, in the first place, that it is liable to inhabit the intestinal canal of various animals; of all those, indeed, in which the larvæ have been found in the muscular tissue. This has been proved by direct experiment; for, by the feeding of dogs, cats, rabbits, rats, mice, pigs, and guinea-pigs with trichinous flesh, the larval Trichinæ have attained their sexual maturity within less than forty-eight hours after their introduction into the new bearer. In six days the female parasites will contain perfectly-developed and free embryos in their interior. Besides the above-named animals, Trichinæ have I believe, also, been obtained from the horse, ox, sheep, and other ruminants. As soon as the embryos have attained their full size within the uterus of the parent Trichina, they voluntarily pass out at the vaginal opening, and commence wandering, as it were, on their own account. They do not, however, as some have supposed, get into the blood-vessels to be transported by the circulation to various parts of the body, but penetrate directly through the walls of the intestinal canal, rapidly making their way through the mucous, fibrous, and cellular tissues, in all directions, until they arrive within the various voluntary muscles of the "host." In this way, some of them reach the extremities and other parts far removed from the spot whence they originally set out, and they seldom stop in any non-muscular organ. In a cat which I dissected many years ago, I found the lungs to contain tens of thousands of microscopic Filariæ, which I have since regarded as referable to this genus; but Leuckart and others, by their experimental methods, have

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* My colleague, Dr. Lieving, informs me that an average-sized man, weighing ten stone, ordinarily carries about four stone weight of muscle. The above calculation is made in accordance with this datum.—T. S. C.

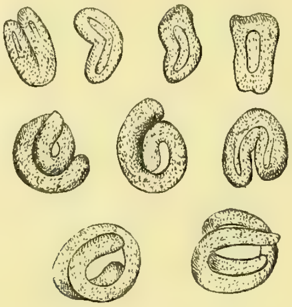

FIG. 74.—Embryos of *Trichina* in various stages of development. (Highly magnified.)—Leuckart.

caught the little larvæ in the very act of passing into and out of the abdominal cavity, and also within various parenchymatous tissues on their way to the more superficial and remote parts of the body. In one of Virchow's earlier experiments, he found the wandering larvæ in the mesenteric glands, as well as in the cavities of the peritoneum and pericardium. The heart itself has occasionally been selected as a permanent resting-place; at least, Virchow saw this in one instance. After the brood has migrated to the territory destined for its temporary sojourn, the voluntary muscles undergo a process of degeneration, the various stages of which have been beautifully illustrated by Leuckart, in his monograph; but the point, which I am more concerned to notice, is the fact that, whilst in the adult condition, Trichinæ will perish only a few days subsequent to the decease of the host in which they happen to dwell, they are, on the other hand, in the larval state, capable of retaining their vitality long after the death of the bearer. M. Davaine kept the larvæ alive in water for a month, but the adult worms perished in cold water in about an hour. Under ordinary circumstances, Davaine's observations lead us to conclude that the adult worms do not survive their hosts above six hours; but the larvæ will live for a long time in flesh which has already undergone putrefaction. In this way, as Davaine very naturally suggests, "the *débris* of an animal devoured by carnivora may become fatal to rodents, or a carcase near a marsh or rivulet may communicate the parasites to the ruminants which drink the water, or to pigs;" for, it is within these last-named bearers that the Trichinæ seem most liable to take up their abode.

From what has now been advanced, it is easy to understand how we ourselves become infected with Trichinæ, and therefore subject to the febrile helminthic disorder termed Trichiniasis; but, before I adduce evidence as to the formidable nature of this malady, it will be well to give a general summary of the facts above recorded, in addition to one or two others which have been purposely omitted. In my paper communicated to the Zoological Society, I have made a brief *résumé* of this kind, based chiefly on the writings of Virchow, but as Leuckart has placed the results of his own inquiries in a somewhat more detailed and exhaustive manner, I prefer to quote the results, as he has himself recorded them :—

1. " *Trichina spiralis* is the juvenile condition of a little round worm, hitherto unknown, to which, however, the generic name of *Trichina* must remain attached."

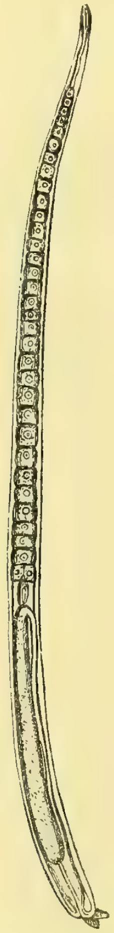

FIG. 75.—Sexually mature male *Trichina spiralis*. (Highly magnified.)—Leuckart.

2. " The sexually-mature Trichina inhabits the intestinal canal of numerous warm-blooded animals, especially mammalia (also of man), and constantly in great numbers."

3. "At the second day after their introduction, the intestinal Trichinæ attain their full sexual maturity."

4. "The eggs of the female Trichinæ are developed within the uterus of the mother, into minute filaria-like embryos which, from the sixth day, are born without their egg-shells."

5. "The new-born young soon after commence their wandering. They penetrate the walls of the intestine and pass directly through the abdominal cavity into the muscles of their bearers, where, if the conditions are otherwise favourable, they are developed into the form hitherto known."

6. "The directions in which they proceed are in the course of the intermuscular connective tissues."

7. "The majority of the wandering embryos remain in those sheathed muscular groups which are nearest to the cavity of the body (abdomen and thorax), especially in those which are smaller and most supplied with connective tissue."

8. "The embryos penetrate into the interior of the separate muscular bundles, and here, already, after fourteen days, acquire the size and organization of the well-known *Trichina spiralis*."

9. "Soon after the intrusion of the parasite, the infested muscular fibre loses its original structure. The fibrillæ collapse into a finely granular substance, whilst the muscular corpuscles change into oval nucleated cells."

10. "The infected muscular bundle retains its original sheathing up to the time of the complete development of the young Trichinæ, but afterwards its sarcolemma thickens and begins to shrivel at the extremities."

11. "The spot inhabited by the rolled-up parasites is converted into a spindle-shaped widening, and within this space, under the thickened sarcolemma, the formation of the well-known lemon-shaped or globular cysts commences by a peripheric hardening and calcification."

12. "The migration and development of the embryos also

takes place after the transportation of impregnated Trichinæ into the intestines of a new host."

13. "The further development of the muscle-Trichinæ into sexually-mature animals, is altogether independent of the formation of the calcareous shell, and occurs as soon as the former have reached their completion."

14. "Male and female individuals are already recognizable in their larval state."

15. "The immigration of the Trichina-brood in masses produces very grave, or even fatal consequences; peritonitis (from the embryos perforating the intestinal walls), pain, and paralysis (from the destruction of the infected muscular fibres)."

16. "In proportion to the quantity of imported parasites, the eating of trichinous meat is also attended with more or less dangerous symptoms (or even death) as its consequence; enteritis with exudation of a croupy mass which is sometimes thrown off in flakes (in rabbits and rats), sometimes in pus-bodies (in the cat and mouse), or (in the dog) becomes converted in psorospermiæ."

Medical importance of the Trichina.—Having thus sketched, in the briefest possible manner, the leading facts connected with the genesis and development of this minute parasite, I proceed, in accordance with my previous promise, to speak of the peculiar helminthiasis resulting from its invasion of our bodies. Even at so late a period as that at which the Sydenham Society issued Dr. Lankester's translation of Küchenmeister's "Manual" of the human parasites, we find it stated that "the immigration of the brood of Trichina appears to take place without any general reaction, as it is also borne without injury for many years" by the infected person; and, it was not until the publication of Zenker's oft-quoted and well-known case of Trichina-disease, that the medical profession became aware of the fact that this tiny parasite was capable of producing disease and death. As has often happened in the instance of other important discoveries, Zenker's fatal case not only, as it were, re-stirred up the experimental helminthologists to further inquiry, but it also led to the detection of the existence of a new form of disease, which appears to be more prevalent in Germany than in any other country.* This fact is, of course, easily explained by the circumstance that the otherwise abstemious inhabitants of the "Fatherland" display a remarkable fondness for chopped raw pork. The Trichina disease, in fact, is endemic in those localities where trichinous flesh is eaten; and, notwithstanding the warnings of scientific men, seconded by the (it is to be feared, little respected) sanatory commissioners, the people seem to persevere in their habits of devouring uncooked meat. In proof of the correctness of what I am now stating, I will quote a few records from certain Hanoverian and other German newspapers, which have recently been placed in my hands. Thus, in the "Leipsiger Zeitung" for December 8, 1863, I find it stated that the Trichina disease has just broken out there. "Six persons have fallen ill after eating raw beef mixed with chopped pork. All of them are workmen and workwomen of a printing-office." Again, the "Neue Hannoversche Zeitung" for December 13, 1863, has the following:—"The death of twenty-one persons in Hettstädt has been caused by the flesh of an English pig, which was reared on a neighbouring estate, together with others; nothing remarkable [in their behaviour] being noticed. Persons qualified to judge affirm that the Trichina appears in pigs of all races, and that since cooking does not always kill the worm, it is necessary, whenever a pig is killed, to examine the meat through a microscope. The signs of this disease in the animal are [said to be] loss of appetite, a hoarse voice, quietness, and aversion to all kinds of movement or running, [the latter function, when attempted, being attended with] dragging of the extremities. The pig in question, however, showed none of these symptoms, being considered *all right;* whilst the unfortunate butcher who killed the pig has since died from eating its flesh." In this quotation I have added a few words in brackets to render the translation more readable, but, otherwise, the facts are stated precisely as I have recorded them. Again, the "Zeitung fur Norddeutschland" for December 18, 1863, says:—"Eighty persons fell ill with the Trichina disease in Plauen, [but only] one died. In Magdeburg, during 1858—62, according to official statements, 300 persons have fallen ill of the disease, and only two died. In Calhe, near Magdeburg, during the summer of 1862, out of thirty-eight persons attacked, eight died; whilst, in Blaukenburg, two died out of sixty. In Hettstädt twenty out of 135."* As a consequence of all this, it is subsequently mentioned, that several butchers in Berlin had agreed amongst themselves to have their meat examined by some competent helminthologist.

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* The development of the Trichina disease is not, of course, confined to any particular country, people, or clime. It is, doubtless, tolerably frequent in the pork-eating people of America, though its existence, as a febrile malady, has hitherto been overlooked. In the Bibliography of this work, I have given reference to no less than four cases of *Trichina spiralis* recorded by Dr. H. J. Bowditch in the pages of the "Boston Medical and Surgical Journal."—T. S. C.

From these records, which it is quite unnecessary to extend, it is easy to perceive that although, in the majority of instances, the Trichina disease does not cause death, yet the percentage of fatal cases is by no means insignificant. The notion that particular breeds of swine are more liable to be infested than others is scarcely likely to prove correct, especially when it is considered how many other kinds of domesticated animals are liable to the same parasite-invasion. On this point, indeed, it is needless to dwell; but in regard to the disease, as it affects the human body, much more remains to be noted. Let us, for example, glance at the phenomena of the disease as they presented themselves in Plauen, a town of Central Saxony. Drs. Boehler and Königsdöffer, who first saw this disease and treated it, state, according to Leuckart, that "the affection began with a sense of prostration, attended with extreme painfulness of the limbs; and, after these symptoms had lasted several days, an enormous swelling of the face very suddenly supervened. The pain occasioned by this swelling and the fever troubled the patients night and day. In serious cases the patients could not voluntarily extend their limbs, nor at any time without pain. They lay mostly with their arms and legs half bent—heavily, as it were, and almost motionless, like a log. Afterwards, in the more serious cases, during the second and third week, an extremely painful and general swelling of the body took place; yet, although the fifth part of all the patients were numbered amongst the serious cases, only one died."

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* Since the above was in MS., a short paper has appeared in the pages of the "Lancet," by Dr. W. Müller. Writing from Homburg, he records the case of a relative of his, at Hettstaedt, whom, on being summoned, he found suffering from the Trichina helminthiasis. Alluding to the epidemic he says:—"Previous to my departure from Hettstaedt, eighteen to twenty persons had died of the Trichina disease, and more than eighty persons were at that period afflicted with the same malady." In the same number of the "Lancet" (for January 23, 1864, at page 100) there is also a leading article directing general attention to "the new disease." The comment is ably written, but the editor must, in the interests of public health and truth, permit me to correct one important error. It is stated (page 101, lines 22—24 from the top) that we get the tapeworm and the hydatid from eating pork. It is true that we obtain one of the tapeworms from swine's flesh; but, as I have elsewhere shown, the destructive hydatids are from a totally different source. These are procured or entertained by our swallowing the ova (containing embryos) of *Tænia echinococcus* after they have made their escape from the alimentary canal of the dog.—T. S. C.

Satisfactory as it may be to note the numerous recoveries which take place, this circumstance is very much marred by the fact that a large proportion of the patients suffer the most excruciating agony. In the main, it will be observed that Boehler's and Koenigsdoeffer's experience, as recorded by Leuckart, corresponds very closely with that given by other observers—the symptoms being also very similar to those produced in the original case published by Zenker. In this case (which occurred in the Dresden Hospital, in the month of January, 1860) the patient was a servant girl, aged twenty, and the principal symptoms were loss of appetite, prostration, violent pains, contraction of the limbs, and finally œdema, which, in association, perhaps, with a certain amount of pneumonia, terminated her career within a period of thirty days. As this case has been quoted by Leuckart, Davaine, Aitken, and many others, and as it has also appeared in several of our English scientific periodicals, I need only add that the *post-mortem* appearances showed that the larval Trichinæ were the cause of death, whilst the intestinal canal contained numerous sexually mature worms, whose direct genetic relationship with these larvæ has since been fully and unequivocally established.

As I have elsewhere remarked, the genesis and migrations of Trichina are astonishingly rapid, and so far as my knowledge extends, without parallel in this or any other class of parasites; and this circumstance, in association with the rapid migration of the numerous progeny, bears a strict relation to the rapidity with which the disease runs through its course. The severity of the symptoms will also, in the main, depend upon the number of the migrating larvæ in the bearer; but there can be no doubt that some persons will suffer less than others, even though they may have swallowed an equal number of Trichinæ. As we have seen also, from the statistical facts above quoted, the prevalence of the Trichina helminthiasis, whether confined to a single family, the community of a particular town, or the population of a large district, bears a strict relation to the quantity of trichinous meat eaten by the aforesaid people. Doubtless there are many unrecorded cases in which so few Trichinæ have been swallowed that the amount of traumatic irritation, produced by their correspondingly small progeny, has been insufficient to excite any particular attention on the part of the unconscious bearer. Supposing even a dozen impregnated female worms gained access to the intestinal canal, each of these producing on an average 150 embryos or thereabouts, the total larval progeny, numbering less than 2000, would probably be incapable of making their presence known or felt within the person of their bearer.

The experiments of Virchow, Leuckart, and Davaine, all tend to show that the effects produced on animals by the Trichina are very similar to those occasioned in man. All three of these *savans* have minutely recorded these phenomena. As they have, however, been described and summarized by the last-named author in a memoir recently communicated to the Biological Society of Paris, I shall close this chapter by a quotation from the paper in question, from the careful translation (out of the "Gazette Médicale de Paris") published in the "British Medical Journal" for the 25th of April, 1863 (New Series, No. 121, p. 426). After alluding to the interesting fact that it is only during the brood-migration that we meet with the Trichinæ in the serous cavities, glands, and cellular-connective tissue, Davaine observes that the symptoms produced by these parasites in animals may present these successive and more or less distinct phases :—

"The first phase is characterised by intestinal disorder produced by the development of the larvæ in large numbers, and their adhesion to the mucous membrane of the intestine. In this stage, M. Davaine has seen rabbits die with intense diarrhœa; one of two cats which he fed with trichinised meat had diarrhœa for at least a fortnight, but survived. Of five or six rats fed on a similar diet, one only, which was pregnant, died of diarrhœa, after abortion on the eighth day. According to M. Leuckart, the passage of the embryos of Trichinæ through the intestinal walls sometimes produces peritonitis. This intestinal phase often becomes blended with the next; it may be relieved by the expulsion of the worms by means of the diarrhœa, or may cease with the natural death of the worms.

"The second stage presents general symptoms—muscular pains, etc. These phenomena are dependent on the introduction of the Trichinæ into the muscles; they rapidly acquire their maximum intensity, and have not a long duration. The appearance and duration of this stage are in complete relation with the development and length of sojourn of the Trichinæ in the intestines; in fact, in this entozoon, oviposition is not slow and of long duration, as in many nematoid worms; the genital tube is rapidly formed, and the ova, in its whole length, are developed almost simultaneously, so that the embryos, arriving soon at maturity, are at once thrown out in large number into the intestine, and the mother Trichina dies exhausted. If it be remembered that the embryos do not escape before the eighth day, that a certain number of days are required for their arrival in the muscles, and that new ones are not produced after six or seven weeks, it will be understood that the first symptoms of this stage can scarcely appear until the end of a fortnight after ingestion of the diseased food, that they must continue four or five weeks, and that after this they may disappear. This course of events is observed in animals; and in man, the symptoms of this stage have shown themselves and become aggravated from the third to the sixth week after infection. Most animals die during this stage; rabbits rarely survive; rats, on the contrary, generally resist it.

"If the animals do not die of the general symptoms or local disturbances proper to these two stages, the inflammatory symptoms cease, respiration becomes natural, and order is re-established. But, in some cases, the number of cysts formed in the muscles are sufficiently great to impede them in the proper exercise of their functions, and hence arises general debility, a kind of consumption which persists or becomes aggravated, and the animal dies of marasmus. M. Davaine has noticed this in rabbits, but especially in a rat.

"Recovery from these phases of trichinal infection may be apparently perfect. A rabbit, which M. Davaine kept during five months, became large and fat, although it had a large number of Trichinæ in its muscles; a rat which had had these Entozoa in considerable numbers during six months, was, to all appearance, in good health. Hence he concludes that the Trichinæ produce symptoms only when they are in the intestinal canal, and when they are entering the muscles. Having become lodged in their cysts among the muscular fibres, they may remain harmless for an indefinite time. In every case except one, down to 1859, Trichinæ have been found in the bodies of persons who have died of disease (generally chronic) or by accident; or in the dissecting-room, in bodies regarding which the previous history could not be obtained. In most cases, the cysts contained a cretaceous or fatty deposit, showing that they had probably existed several years.

" The observations which have been made on the human subject, in regard to the symptoms caused by Trichinæ, show that they belong, as in animals, to the initial period of infection. They consist in intestinal and in muscular lesions; the latter coincide with the entrance of the parasite into the muscles, and are truly traumatic. In Zenker's case, the intestinal symptoms were swelling and pain; in a case described by Friedreich, diarrhœa was present. In all cases, the most remarkable symptoms were violent rheumatoid pains in the muscles, not in the joints, which were considerably aggravated by attempts to extend the half-bent limbs. The other symptoms have been variable, but have had a strong resemblance to those of typhoid fever. In several cases there has been abundant sweating; and in one there was a very remarkable miliary and furuncular eruption. The animal heat was diminished in Friedreich's case; and in those observed in Voigtland by Freytag, the temperature never exceeded 102° Fahr.

" The progress, duration, and severity of the disease in man are in relation to the number of Trichinæ taken into the digestive canal. Of sixteen patients observed at Plauen by Drs. Boehler and Kœnigsdœffer, eight, who were moderately affected, recovered in a month; four, more severely diseased, were ill two months; of four others, one died with ascites and colliquative diarrhœa at the end of two months, and three recovered slowly at the end of three or four months. Recovery does not imply the death of the Trichinæ; it follows their enclosure in cysts.

" The diagnosis of trichinal infection has several times been made in the living human subject by removing a portion of muscle. M. Davaine thinks it probable that, during the first six or eight weeks of the disease, the diagnosis may be confirmed by searching for adult Trichinæ in the alvine evacuations, produced naturally or by means of a purgative.

" The prophylactic treatment consists simply in the avoidance of uncooked meat. The medicinal treatment must vary with the stage of the disease. At first, attempts must be made to expel the parasites from the intestines by purgatives and anthelmintics. Which, among the latter, is the most energetic and certain is not yet determined: calomel is, perhaps, M. Davaine thinks, the best. After six or eight weeks, all treatment directed towards the intestines is superfluous. It is scarcely probable that any substance will act on the larvæ disseminated through the muscles. Friedreich has recommended picronitrate of potash; but in the case in which he used it, live Trichinæ were found in the muscular tissue after the patient was considered to be cured."

At the risk of repeating one or two minute particulars which I had previously recorded from Leuckart and others, and also from the Hanoverian newspapers; and rather, moreover, than mutilate this part of Davaine's succinct summary, I have preferred to quote the passage as it stands. His memoir, indeed, is a remarkably complete one, but on going over it, I do not find any important particulars (other than the above) which I had not before gathered from Leuckart, Virchow, Küchenmeister, and other writers of less distinction.* At present I have not myself enjoyed an opportunity of experimenting with this particular parasite, although, some time ago, I saw two subjects in which the voluntary muscles were extensively invaded by Trichinæ. At that time, Zenker's case had not been made public; but, from my recollection of the circumstances connected with the death of one of the above-mentioned persons, I entertain little doubt that the fatal result was due to the larvæ of the formidable little parasite which we have just considered. So far as I am aware, no successful experiments have been performed with *Trichina spiralis* in this country, although it appears that some few were attempted by part of the members of the Edinburgh Physiological Society. Mr. Gamgee, nevertheless, in the pages of the "Popular Science Review," has recently offered some interesting observations on the prevalence of diseased meat in different countries. "Did Moses," asks the veterinary professor, "know more about pigs than we do? Was it a knowledge of the parasitic diseases common to man and swine which led the father of the Jews to condemn pork as human food? Both questions can be answered in the negative; and the apparently slender grounds on which pigs were first regarded as unclean are stated in the following verse:—'And the swine, because it divideth the hoof, yet cheweth not the cud, it is unclean unto you: ye shall not eat of their flesh, nor touch their dead carcase.' The wisdom of the Mosaic law can only be justly estimated with a knowledge of the accidents arising in warm countries from eating pork throughout long and hot periods of the year; and there is no doubt that the direct evil results as manifested by human sickness led to the exclusion of pork from the list of Israelitish viands. The masses of measly pork which may be seen hanging from the butchers' stalls in Southern Europe prove that the long-legged swine which hunt the forests for acorns, and rove about to pick up all kinds of offal, are often unfit for human food, and that they were so to no less extent in the land of Israel is probable." As regards the Mosaic opinions on these points, and more especially on the question as to the parasitic nature of the "fiery serpents" of the wilderness, I may remark that this subject has been most ably and fully discussed by Küchenmeister in his well-known treatise on human and animal parasites. The prevalence of trichinous disease in this country, however, as I have already attempted to show, is a matter of much higher practical importance, and, consequently, Mr. Gamgee's observations on this latter score are still more cogent:—"It is interesting," he says,

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* In a foot-note (p. 337), I have already referred to the admirable *résumé* which first appeared in the pages of the "Medical Times and Gazette" (for April, 1864). The author dwells more particularly on the question of the prevention and cure of Trichiniasis, and especially, also, on the harpooning method of diagnosis. About three months previously, Dr. Thudichum published an account of the flesh-worm epidemic as it had occurred in Germany. This paper appeared, anonymously, in the "British Medical Journal," and, from the ardent terms in which it was communicated, naturally excited considerable attention. On comparing the data therein set forth with those derived from other sources, one cannot fail to notice a considerable divergence of statement as to the actual numbers of persons attacked with Trichiniasis. In the main, however, the various records are sufficiently harmonious. Very lately, at a *soirée* held at the Royal College of Physicians (June, 1864), Dr. Thudichum exhibited some living Trichinæ and flesh-worm harpoons, which he had received from Germany.—T. S. C.

"to observe that parasitic maladies in the pig specially abound in that section of the United Kingdom where swine live most amongst human beings. The Yorkshire and Berkshire pigs, in their native counties, inclosed in the farmyards of their breeders, are free from worms which are likely to live in the body of man. The Irish pig is the one most commonly injured by Entozoa, and the reason for this is evident when we know how much the cottager relies on rearing a porker which is permitted the free range of house and road, where every description of filth is devoured, charged with the ova of parasites expelled by man, or some of the lower animals." He also adds, "The conditions under which we live in the British isles are certainly much less favourable to the propagation of worms; but we disregard, in our ignorance, the most common precautions to protect ourselves from loathsome diseases, and not only permit dogs to eat any kind of offal in and around slaughterhouses, but sanction the existence of piggeries where all kinds of garbage, charged with worms or their eggs, are daily devoured by swine. The majority of germs calculated to engender parasites are to be found in abundance in the contents of the alimentary canal of human beings and domestic quadrupeds. If pigs are permitted to eat these, as in Ireland or in many British piggeries, we must expect hams, bacon, and pork sausages to be charged with the embryonic forms of human Entozoa. Whereas, in Iceland, then, the dog is the victim of human negligence, and *en revanche* the cause of human disease, in the British Isles the pig holds this unenviable position: the more, however, we learn of parasitic disease in man, the better we can understand how even the underdone roast beef of Old England may prove to us poison as well as food, and how the dog or the cat we pet may indirectly shorten our days. We have good reason to believe, with Moses, that the pig is an unclean beast; but without discarding him from the scanty list of animals to be eaten, it is evident that we can purify the race of swine, and thus prevent human as well as porcine maladies."

Such considerations as these must surely tend to open the eyes of the general public, and show them how much they stand indebted to our recent entozoological discoveries. In my opinion, the members of the Committee of the Royal Society for the Prevention of Cruelty to Animals, by offering money rewards for Essays, do very serious harm to their fellow-creatures—at least, if by such means they succeed in putting a stop to those necessary experimental inquiries, by which we arrive at a knowledge of the way in which our bodies may be preserved from parasite-infection. If they can prove that the human individual is of no more value than many Entozoa, then, by all means, stop our self-denying labours and investigations, and let the parasites invade our frames at will.

CHAPTER XIII.

STRONGYLUS BRONCHIALIS.

General and specific characters of *Strongylus bronchialis* and *Eustrongylus gigas*—Organization of the latter—Characters of *Sclerostoma duodenale* and *Oxyuris vermicularis*—Conflicting statements respecting the anatomical peculiarities of the Oxyurides—Opinions of Eberth, Küchenmeister, Walter, Schneider, Davaine, Claperède, and others—Development—Injurious effects on man—Treatment.

Although we are at present but very imperfectly acquainted with the phenomena connected with the life-history of the human nematode species which still remain to be described in this work, yet, from the data furnished by the habits of the larvæ of Trichinæ, there can be little doubt that we are now on the eve of fresh discoveries; and, it may be added, this desirable result is likely soon to show itself, because both in this country and abroad, a small but vigorous band of helminthological workers are busily engaged in experimental inquiries. Without further prelude, I hasten to consider these remaining parasites:—

26. Strongylus bronchialis.

S. bronchialis, Cobbold.
S. longevaginatus, Diesing; Küchenmeister; Weinland.
Filaria bronchialis, Rudolphi; Owen; Leidy.
F. hominis bronchialis, Rudolphi; Dujardin; Diesing; etc.
F. lymphatica, Moquin-Tandon.
Hamularia lymphatica, Treutler; Jördens.
H. subcompressa, Rudolphi; Bremser.
Tentacularia subcompressa, Zeder.

General and Specific Characters.—A moderate-sized nematode helminth, the male measuring rather more than half an inch, whilst the female is upwards of an inch in length; caudal appendage of the male furnished with a bilobed, membranous, semi-bell-shaped bursa, or accessory organ of copulation, which surrounds the cloacal outlet, the latter concealing an intromittent organ, consisting of a double spiculum; tail of the female sharply pointed, the anal orifice being a little in front or above the narrow part; body filiform, of a pale yellow colour, $\frac{1}{50}$ of an inch broad in the male, and $\frac{1}{35}$ in the female; mode of reproduction viviparous.

Concerning this species I have only to repeat the opinions which I enunciated some time ago in my paper communicated to the Zoological Society.

Diesing and Weinland have expressed their suspicions as to the identity of *Filaria bronchialis* with *Strongylus longevaginatus;* whilst Küchenmeister has gone further, and pronounced them to be one and the same species. Concurring in this view, I have thought it right to combine the specific title originally given by Rudolphi with the generic allocation employed by Diesing; and if helminthologists generally adopt our views of their identity, I think they will admit the propriety of the nomenclature here superscribed.

The original specimens were discovered by Treutler in Germany, during the winter of 1791, in the bronchial glands of an emaciated subject; whilst those sent to Diesing for description were discovered by Dr. Fortsitz at Klausenberg, in Transylvania, in the lungs of a boy six years old.

The only practical observation which I need offer is to the effect that this parasite, like the closely-allied species (*Strongylus paradoxus*) from the pig, and that from the calf (*S. micrurus*), is undoubtedly capable of causing death by suffocation, at least, when present in any considerable numbers. As to treatment, it is obvious that a powerful expectorant might facilitate the discharge of the worms from the larger bronchial passages, and thus considerably relieve the patient. For some other points connected with the prognosis and prophylaxis I would invite attention to the observations I have already advanced (in the first part of this work) respecting, more particularly, the *Sclerostoma syngamus* and the *Prosthecosacter inflexus.*

27. EUSTRONGYLUS GIGAS.

E. gigas, Diesing.
Strongylus gigas, Rudolphi; Otto; Cuvier; etc.
S. renalis, Moquin-Tandon.
Ascaris renalis, Gmelin.
A. visceralis, Gmelin.
A. canis et martis, Schrank.
Fusaria renalis, Zeder.
F. viceralis, Zeder.
Lumbricus in renibus, Blasius.
L. martis et canis renalis, Redi.
L. sanguineus in rene canis, Hartmann.
L. gulonis sibirici, Pallas.
Diocotophyme, Collet-Meygret.

General and Specific Characters.—The largest nematode helminth at present known to infest the human or any other "bearer;" the male measuring from ten inches to a foot in length, and $\frac{1}{4}$ of an inch in breadth, whilst the female is said to attain a length of over three feet, its transverse diameter being fully half an inch; body cylindrical, and more or less deeply tinged with redness; head obtuse and furnished with a simple oral aperture, surrounded by six papillæform, chitinous nodules; caudal extremity of the male displaying a simple round, cup-shaped bursa, devoid of any radiating appendages; penis consisting of a single spiculum; tail of the female bluntly pointed, and pierced by the anal aperture; vaginal orifice situated on the ventral aspect, at a short distance below the so-called head, mode of reproduction probably viviparous; eggs broadly oval, measuring about $\frac{1}{300}''$ from pole to pole.

Though fortunately very rare in man, this worm is known to occur in a great variety of animals, especially in weasels. According to Weinland and Jackson, it is particularly abundant in the kidney of the North American Mink (*Mustela vison*, Cuvier), destroying the substance of the organ, the walls of which become the seat of calcareous deposit. It has been found in the dog, wolf, glutton, raccoon, coati, otter, seal, ox, and horse.

The anatomy of *Eustrongylus gigas* has been more or less fully described by Otto, Owen, Blanchard, and Chabert, and also, briefly, by Küchenmeister and Davaine. All of them recognise a well-defined nervous system; but further researches are needed to explain away certain discrepancies in their writings, and especially also in regard to the water-vascular system, the very existence of which (in nematodes generally) is, I believe, denied by Dr. Williams of Swansea. According to the description given by Davaine, "the integument of the female is thick, fibrous, and bordered internally by a layer of rounded and denticulated papillæ. The intestine is large, blackish, apparently very thin, and attached to the integuments on either side by cellular or muscular bands. The free extremity of the ovary or the testicle (in the male) is fixed near the anus. The ovary and oviduct, which are continued from it, or the testicle and *vas deferens* forming a simple tube, are directed forward from that point to within a certain distance from the head, and are supported throughout their course by the bands which connect the integuments with the intestine. The genital tube subsequently frees itself and makes a great number of convolutions in the general cavity of the body, but without twisting itself round the digestive tube, which latter is attached to the parietes throughout its entire

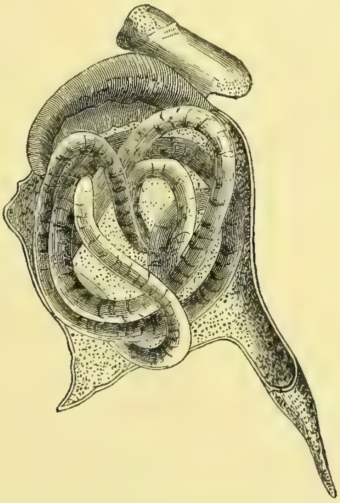


FIG. 76.—Kidney of the Coati (*Nasua socialis*), with *Eustrongylus gigas* coiled within the pelvic cavity.—Leuckart.

course. The straight vagina also passes beneath the bands of the intestine, in continuation of the course followed by the oviduct, and opens at the ventral surface near the mouth. We have, in vain, looked for a nervous system. The nerve-cord seen by Otto was very probably that portion of the genital tube which is fixed by the intestinal bands, and these same bands doubtless constitute the secondary nerve-filaments; but the most superficial examination suffices to show the independent character of these fibres, and of the cord which they thus connect to the parietes. The copulation is probably rather prolonged, because Drelincourt has found two worms sexually united in the intestine of the dog." Davaine, afterwards, questions the validity of the statement made by Wedel as to the viviparous character of this worm. As the enunciation of this opinion dates so far back as the year 1675, it seems a little strange that no one should have distinctly confirmed or refuted Wedel's remark that the body of the female "is filled with a multitude of living embryos (vermicules)."

As regards the injurious symptoms produced by the *Eustrongylus gigas* in the human subject, all I need say is that the general disturbance of the system exhibits very much the same character as that which ordinarily arises from abscess and degeneration of one of the kidneys. As, however, the symptoms might also be mistaken for renal calculus, the possibility of finding the characteristic eggs or embryos in the urine forms a diagnostic consideration which should not be overlooked. In cases where the worm is found immersed in a quantity of sanguineous purulent matter, the parasite, according to Chabert, loses much of its reddish hue; the latter character, indeed, as Küchenmeister has suggested, is rather evanescent, and differs very little from what has been observed in other large Ascarides. I may also remark, that the bright red hue of *Sclerostoma syngamus* is not due to any colouring of the skin, but is owing to the presence of a quantity of bright, sanguineous-looking fluid, occupying the general cavity of the body. In the last-named species, in *Ascaris megalocephala*, and in several other nematodes, I have frequently noticed the variable character of this colouring, and I have, therefore, ceased to lay much stress upon its presence in the matter of specific identification.

28. SCLEROSTOMA DUODENALE.

S. duodenale, Cobbold.
Strongylus quadridentatus, Siebold.
Anchylostoma duodenale, Dubini; Siebold; Pruner.
Ancylostomum duodenale, Diesing; Leidy; Küchenmeister; etc.

General and Specific Characters.—A small nematode helminth, measuring usually about $\frac{1}{3}$ of an inch in length, the females being sometimes considerably in excess of this, but always less than $\frac{1}{2}''$; characterized especially by an asymmetrical disposition of four unequally-sized, horny, conical, converging, oral papillæ, forming the so-called teeth; head slightly pointed and tapering, continuous with a tolerably uniform cylindrical body, $\frac{1}{80}''$ in thickness, and terminating in a straight, cone-shaped, or rather sharply-pointed tail in the female; the caudal extremity of the male ends in a partially inflexed, blunt point, furnished with a cup-shaped, bilobed bursa, the membranes of which are supported by eleven chitinous rays, ten being simple, whilst the median, or odd one, is bifurcated at the summit; mode of reproduction viviparous.

This interesting worm, females and males of which exist in the proportion of three of the former to one of the latter, was first discovered by Dubini at Milan, and though at first thought rare, is now known to be tolerably common throughout Northern Italy. According to Pruner, Bilharz, and Griesinger, it is remarkably abundant in Egypt, the latter authority supposing that about one-fourth of the people are constantly suffering from a severe anæmic chlorosis, occasioned solely by its presence in the small intestines.

From the accurate descriptions of Siebold, it becomes quite evident that this worm is closely allied to his genus *Syngamus*; and, as he has himself remarked, it might have been placed in the genus *Sclerostoma*. In this genus I have arranged it, because the asymmetrical disposition of the so-called dental organs is not, of itself, sufficient for the establishment or retention of Dubini's genus *Anchylostoma*; otherwise, out of respect for the discoverer, I would have preferred his nomenclature. *Sclerostoma duodenale* closely resembles the little worm (*Syngamus trachealis* of Siebold, *Sclerostoma syngamus* of Diesing) which gives rise to the "gapes" in birds; but the male of the latter species is comparatively small, whilst the vaginal outlet of the female is placed much further forward. Küchenmeister's "Manual" furnishes an excellent account of the "Ægyptian chlorosis" said to be produced by the *Sclerostoma duodenale;* a tolerably minute account of the symptoms and pathological appearances being also given by Davaine in his admirable work (Part I., pp. 117—120), which I have several times referred to; and those who are interested in checking the "gape disease" of fowls I may be permitted to refer to my memoir on "*Sclerostoma syngamus*," in the fifth volume of the "Journal of the Proceedings of the Linnean Society," (Zool. Div., p. 304) an abstract of it being likewise given in the first part of the present work (p. 84-91).

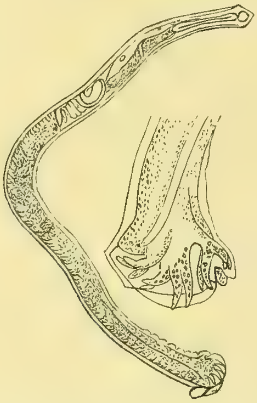


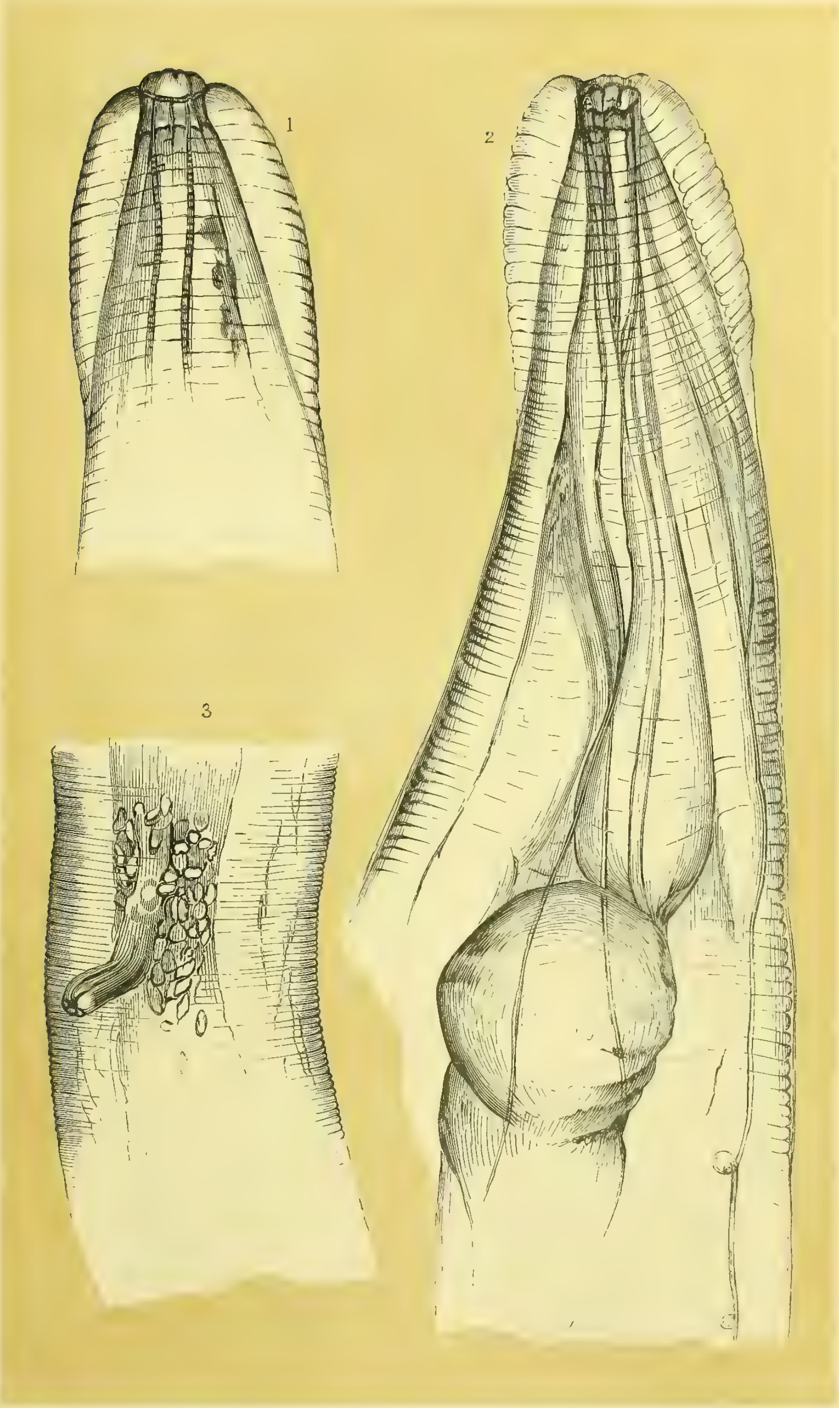
FIG. 77.—Male example of *Sclerostoma duodenale* (enlarged); with a separate view of the caudal bursa (more highly magnified).—Küchenmeister.

29. OXYURIS VERMICULARIS.

O. vermicularis, Bremser; Chiaje; Dugés; etc.
Ascaris vermicularis, Linneus; Müller; etc.
Fusaria vermicularis, Zeder.

General and Specific Characters.—A small nematode helminth, the male measuring scarcely the $\frac{1}{6}$ of an inch in length, whilst the female varies from $\frac{1}{3}''$ to very nearly $\frac{1}{2}''$, the latter especially characterized by a long and gradually-tapering capillary tail, ter-

PLATE XVIII.



Oxyuris vermicularis Bremser.

G. Busk, delt.

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minating in a three-pointed end, which is said to act as a kind of holdfast; the caudal extremity of the male being obtusely pointed; both sexes present a more or less fusiform body, the anterior end being narrowed to form a somewhat abruptly-truncated head, which is often rendered very conspicuous by a uniform transparent bulging of the integument surrounding the mouth, and presenting in profile the aspect of winged appendages; oral opening tripapillated, leading into a triangular œsophagus; integument transversely striated, and of a silvery-white appearance; penis simple, single, and very minute; mode of reproduction oviparous; eggs oblong, unsymmetrical, measuring about $\frac{1}{1400}''$ from pole to pole, and $\frac{1}{900}''$ in their greatest transverse diameter.

Of all the parasites infesting the human body, this is the one concerning which the medical practitioner is most frequently consulted, partly on account of its remarkable frequency in children, and more particularly on account of the extreme difficulty experienced in getting permanently rid of it. The *Oxyuris vermicularis* is, however, by no means confined to young persons, seeing that some adults are troubled with it even to old age. Speaking, more precisely, as to their habitat, these worms commonly infest the terminal portion of the intestinal tube, being especially abundant in the sigmoid flexure of the colon.

Anatomical Peculiarities.—In the main, it may be said that the structure of Oxyuris conforms with that of Ascaris, but there are a few well-marked differences; and when we come to enter minutely into the subject, which here, indeed, we do not propose to do, it is lamentable to find the discrepancies which exist amongst our leading helminthologists. At one time, we are called upon to express our admiration of Walter's great discoveries respecting the nervous system of *Oxyuris ornata*, and, shortly afterwards, we are equally compelled to admire the coolness with which he stands prepared to admit that his wonderful display of nerve-cords, filaments, unipolar, bipolar, and multipolar ganglion cells is altogether a mistake. In like manner, Otto, Meissner, and Wedl, made several so-called nerve-discoveries in other nematoda, but these supposed nerves, according to the observations of Schneider and Leydig were only parts of the muscular system, or, in one case, of the œsophagus! All this is highly unsatisfactory, and tends to throw doubt upon the general value of histological observations among the helminths.

Without attempting to rectify these discrepancies, I shall content myself with giving a mere outline of the structure of Oxyuris according to views usually accepted, whether they be right or wrong. And, first, as regards the integument. This consists of a true skin layer and an extremely-delicate, transparent, structureless epidermis. The corium is described as consisting of dense fibres, some of which are spirally and others transversely directed; these appearances I have not myself seen, and I feel tolerably certain they are illusive phenomena. In all cases, as in other nematodes, we find the characteristic, regular, transverse rings, which are beautifully distinct in the vesicular production surrounding the mouth. The muscular system consists principally of four longitudinal masses, two dorsal and two ventral, which pass from the

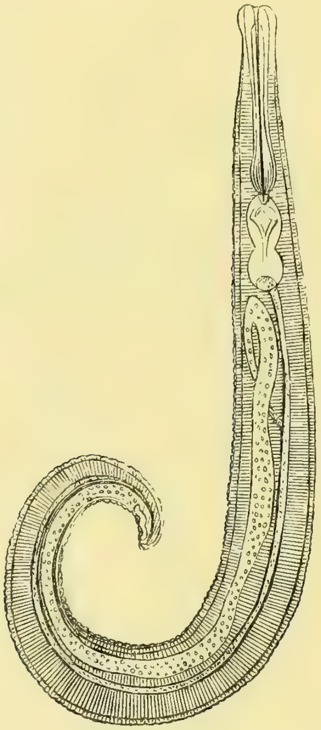


Fig. 78.—Male *Oxyuris vermicularis*. (Highly magnified.)—Küchenmeister.

mouth to within a short distance of the tail. The general parenchyma of the body consists of loose cells lining the central cavity of the body, and some of these appear to be differentiated into special organs of secretion, thus becoming recognized as glands. These glands abound in all parts of the bodies of nematoda, though they are usually most conspicuous towards the anterior part. Some of them attain great size, as I found in the case of a sexually immature round-worm, *Ascaris collaris* (Linn. Trans., Vol. xxii., Tab. 32, Fig. 27).

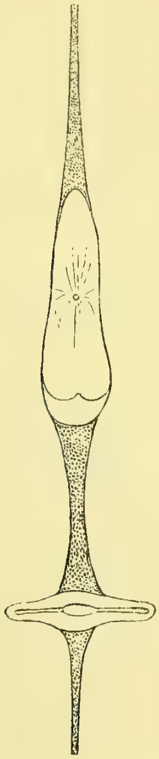


FIG. 79.—Special gland, within the ventral line, immediately in front of the vaginal outlet. (*Oxyuris ambigua.*) (Considerably enlarged.)—Eberth.

A great deal of confusion occurs in respect of the water-vascular system and its connection with the glandular elements. Some authors describe, for example, a perforated ventral sucker, which, however, is admitted to disappear as age advances. "In *Oxyuris ambigua* and *Ascaris oxyurus*," says Eberth, "in the ventral line, there lies above the vaginal opening a roundish or oval sac, bounded by a delicate wall, which opens through a short narrow passage to the outside by a fine opening. Towards the upper and lower end of the sac the ventral line becomes broader, so that one may say the sac lies in a special widening of the ventral line. In this I recognise the simplest form of the glands, which in many nematodes open at the ventral surface." If Eberth's description be correct, this so-called sucker may be regarded as a special gland orifice.

Respecting the water-vascular system itself, it may be remarked that we have here four well-marked longitudinal vessels, one dorsal, one ventral, and two lateral, occupying their usual situation. According to the age of the Oxyuris they seem to present very different appearances; at least, this must be the case, if they are to be regarded as identical with Walter's so-called fat-canals. In the adult *Oxyuris ornata*, this observer finds the dorso-ventral canals narrower than the lateral ones, these side vessels giving off numerous delicate branches. On this point, however, the views of Eberth are somewhat at variance with those of Walter. Speaking of *Oxyuris ambigua* and *Ascaris oxyura*, Eberth remarks that he finds "two comparatively stout, sometimes slightly curved lateral vessels, each consisting of a stouter tube, including a small delicate-walled vessel, the space between the two being filled up with a finely granular mass. The central canal is bounded on either side by a single row of small nuclei. The dorso-ventral vessels are small canals filled with fine granules." Walter speaks of anastomoses between certain of these longitudinal vessels, but in Eberth's experience they do not exist. Many other points of dispute might be brought forward concerning the water-system, but one's patience gets exhausted when one finds no two observers exactly agreed.

Again, as regards the nervous system, it is difficult to speak with positiveness, notwithstanding the asseverations of Schneider, Walter, and Eberth. Probably all that may be said with certainty is that a pale band, forming the œsophageal ring, exists a little below the mouth, and from this ring several fine filaments pass off in different directions, and stand connected, more or less conspicuously, in their course, with numerous large granular cells, which are confidently affirmed to be ganglionic in their character.

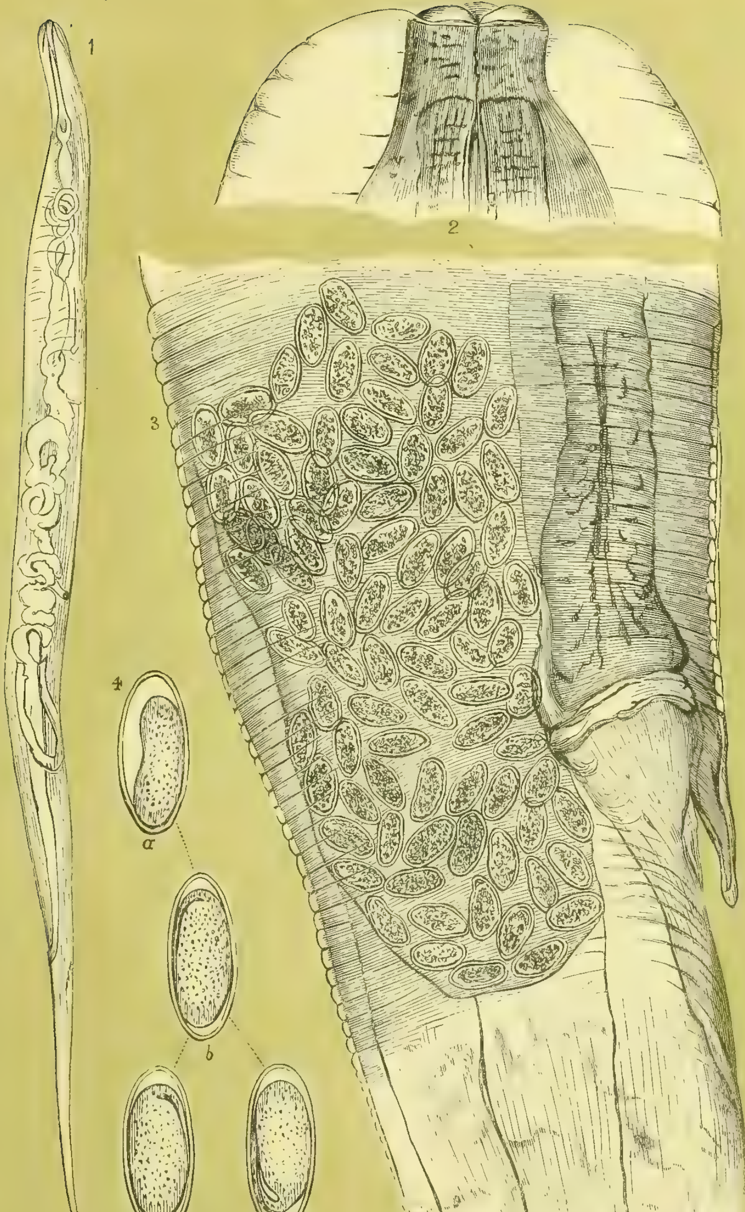
Fortunately, one can speak a little more precisely as regards the digestive system. In the centre of the space occupied by the large external lateral vesicular expansions, one perceives three well-marked oral papillæ, which can be withdrawn so as to leave the oral opening rounded and simple. The mouth communicates directly with an elongated, club-shaped œsophagus, which, though cylindrical in the mass, encloses a central triquetrous canal. A sudden constriction of the cylinder leads to the formation of a strong spherical œsophageal bulb, which Küchenmeister has compared to a gizzard, because the interior of it is occupied by a peculiar valvular apparatus. These tooth-like, crushing organs, however, are by no means uncommon in other nematodes. Immediately below the bulb, the true stomach makes its appearance in the form of a club-shaped mass, which insensibly merges into the intestinal canal, the latter again widening a little in front of the anal orifice.

The reproductive organs, in the male, consist of a simple cylindrical testicular tube, which is folded upon itself at the upper part, and terminates below in a cloacal cavity common to it and the intestinal tube. It is furnished with a small retractile infundibuliform penis or spiculum, which is slightly curved and imperforate. In the female the generative organs comprise a short utero-vaginal canal, two very broad uterine horns, which, in the sexually-mature condition are so crowded with eggs that they frequently obscure all the other neighbouring parts, and two narrow ovarian cœcal filaments, in which the germs and granular yelk are formed. The vaginal opening is simple, and, like that of the intestine, is placed on one and the same side of the body; the tube consists of a dense fibrous membrane, being directed obliquely downwards with a slight curvature.

Development.—This is a subject of great importance, inasmuch as our knowledge of the entire life-history of *Oxyuris vermicularis* may eventually lead us to adopt some plan by which its access to our bodies may be prevented. At present we know very little; but it is generally supposed that the adult animal may be reared from the egg in one and the same bearer. I believe this notion to be entirely fallacious; yet, on this hypothesis, Küchenmeister has asserted that "the emigration of a single pregnant female Oxyuris is sufficient to explain the infection of entire families." Küchenmeister, indeed, does not appear to have seen the embryos of Oxyuris, for he says that after keeping the eggs for six months in water, he could discover neither mature embryos, nor a distinct segmentation. Very different, however, has been my own experience in this respect, for not only have I constantly found the ova in impregnated oxyurides in all stages of yelk-segmentation, but, in a very considerable proportion of the fresh specimens, I have almost invariably discovered well-formed, tadpole-shaped embryos. With these embryos I have conducted a variety of experiments, but at present the results are chiefly of a negative character.

The only author who appears to me to have given a correct figure and description of the embryo as it appears in the egg, is Claperède. In his scholarly memoir, "De la Formation et de la Fécondation des Œufs chez les Vers Nématodes," he writes, in reference to the ova of *Oxyuris vermicularis*, as follows:—"The egg, which exhibits the form of a very narrow disk in the ovary, acquires the shape of an elongated ellipsoid in the oviduct, and at the surface differentiates itself into a very thick vitelline membrane. Then it forms a strong and resisting chorion, which imparts to the egg an outline similar to that of a bridge's span. It has an oval figure flattened at one of its sides. This chorion is very fragile. It frequently gives way under slight pressure from the thin plate of glass which covers the object. It extends itself con-

PLATE XIX



Oxyuris vermicularis, Bremser.
(Eggs and embryos.)

G. Busk & T. S. C., delt.

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siderably under the action of acetic acid, acquiring a size three or four times greater than that of the egg. The constitution of this chorion is perfectly identical in the eggs both before and after impregnation. It is, nevertheless, easy at first sight to know whether or not we have to deal with a fecundated egg. In the impregnated females the uteri are filled with thousands of ova, each one of which encloses an embryo already well formed. The ventral surface of the embryo and its tail face, without exception, the flattened side of the egg. The embryo is very broad in the body, and occupies all the interior space. An embryo such as Küchenmeister has represented under the form of a small filiform worm folded on itself, and only occupying a very small part of the cavity of the egg, is never to be seen. In the non-fecundated females, on the other hand, the uteri are filled with eggs, which, instead of the embryo, enclose a non-segmented yelk furnished with a large germinal vesicle. This vesicle is not visible so long as the eggs have the form of thin disks ; it only shows itself when the egg begins to acquire an elliptical form in the oviduct. It is, however, probable that this vesicle is the same which was originally visible in the ovary." The chorion itself is homogeneous, but in an allied species (*Oxyuris spirotheca*) Gyoery and Claperède have discovered that this egg-covering consists of spirally coiled bands resembling the tracheal spiral fibre of an insect. I may here also mention that I have observed precisely similar appearances in the chorion-like investment surrounding a minute nematode larva lodged in the intestinal mucous membrane of a heron (*Ardea*). This may help us to establish the genetic relations of the species in question.

Respecting the migrations of the larvæ, I am not aware that anything very definite is yet known. I have introduced the eggs containing embryos into various animals, but have not yet succeeded in rearing young Oxyurides. I have also introduced them into the pulpy parenchyma of apples and pears, but I have not been able to satisfy myself that any of the young nematodes which I subsequently procured, by thousands, in one or two of the pears, were the result of these experiments. I showed some of these living larvæ to Leuckart, who thought they might be *Anguillulæ ;* and, certainly, I never saw the tadpole-like larvæ, as such, out of their shells. The young nematodes, in question, displayed a very different form. As my experiments are in the act of being repeated, I will now say no more on this head.

Injurious Effects on Man ; Treatment.—Küchenmeister and Davaine have written fully on this part of the subject, and the professional journals both at home and abroad teem with recommendations as to the best methods of getting rid of these troublesome invaders. Undoubtedly these worms occasion great annoyance, and, even, grave consequences, by the irritation they set up during their nocturnal wanderings. People of almost every clime seem to be liable to their assaults, these pests being as abundant in America as they are well known to be in Europe and Africa.

As I have before remarked, they are not exclusively confined to children, though most frequently found in young people. The symptoms they give rise to chiefly develop themselves in the evening and at night-time, consisting ordinarily of a painful sense of heat and irritation within and around the anus. These symptoms frequently become excessively distressing, especially when they are accompanied by itching in the neighbouring genito-urinary passages, produced by the migration of the worms about these parts. The local inflammatory symptoms thus set up, occasionally superinduce various sympathetic phenomena, which show themselves in restlessness, general nervousness, itchings at the nose, involuntary twitchings, chorea, convulsions, and, sometimes, epileptiform seizures. Many other local disorders are also set up, especially in cases where they occur at early puberty. The nature of these it is quite unnecessary to enlarge upon, as the subject is fully treated of in purely professional works, as well as by the two authorities above quoted. The same, of course, may also be said in regard to the treatment of the thread-worm helminthiasis. These authors, first of all, recommend the exhibition of ordinary anthelmintic purgatives, which will frequently carry off great numbers. The etherial extract of the male shield fern, Kousso, panna, and the other remedies I have mentioned when treating of *Ascaris lumbricoides*, may all prove useful; but, undoubtedly, the best thing to do, in bad cases, consists in the administration of oft-repeated enemata. These may consist of cold or slightly tepid water, to which it will be well to add either a little salt, or a few drops of anise oil. Some practitioners add assafœtida, or infusions of quassia, and common wormwood. The active principle of the southernwood (*Artemisia abrotanum*) and Tartarian southernwood (*A. santonica*) may also be employed with great advantage. This, in children, may be given either by the mouth, in doses of two or three grains, or along with enemata, when a larger quantity may be employed, previously mixed with some oleaginous material. Simple olive oil was successfully employed by Sömmering, and the decoction of aloes has been recommended by Dujardin. Chloroform, sulphuric ether, and Prussian blue (*Ferri cyanuretum*) have also their various advocates. At all events, whatever anthelmintic be employed, the great thing to be observed is perseverance in the use of the remedy. A good enema, every third or fourth day for two or even three weeks, will scarcely fail to carry off the majority of the obnoxious visitants; and even should they return, we, at least, may expect a tolerably comfortable interval of three or four months. Many persons, however, will not subject themselves to these diagreeable remedies, preferring rather to entertain their numerous guests. One such individual constantly supplies me with fresh *Oxyurides* for experimental purposes; and, as I reward him liberally, his intestinal guests are not, I trust, considered unremunerative. I may here mention, that I am indebted to Mr. Harris for a very useful practical hint, inasmuch as he has informed me that the introduction of a little mercurial ointment within the verge of the anus, when the patient retires to rest, will effectually prevent the nocturnal migration of the parasites. Lastly, there is one Indian drug which appears to be very valuable, because it exerts a specific action on the parasite. It is, in point of fact, a true Oxyuricide; and Dr. Bradley states (according to Waring) that "the natives squeeze the juice of the plant into wounds, to kill worms or maggots." It is the *Aristolochia bracteata* of Roxburgh, and others; by the Hindoos being termed *Keera-mar* (worm-killer). It is given in the form of infusion, and seems to be very efficacious, not only with *Oxyuris vermicularis,* but also in cases of *Ascaris lumbricoides.*

CHAPTER XIV.

DRACUNCULUS MEDINENSIS.

Importance of the Guinea-worm in reference to the disease termed *dracontiasis*—Principal authors who have written on this subject—General and specific characters of *Dracunculus medinensis*—Geographical distribution—Anatomical structure of the adult female—Organization and development of the embryos—Treatment and precautions to be observed—Summary—Brief notice of a second species.

If, in reference to the welfare of Europeans, we recognize the importance of making ourselves acquainted with the nature and origin of the Trichina disease, the pork-measles, the hydatid helminthiasis, and several other maladies of parasitic origin, it is none the less binding upon entozoologists to work out the various unsolved problems relating to the ravages produced in tropical countries by the guinea-worm. What Bilharz, Greisinger, J. Harley, and others, have done in reference to the formidable fluke disease as it prevails in Egypt and elsewhere, Carter of Bombay has been endeavouring to accomplish in reference to the *dracontiasis* of India. In these investigations, Carter has been assisted and partly anticipated by Busk, Owen, Jacobson, and others; whilst, more recently, Robin, Leblond, and especially Bastian, have added important anatomical details. About ten years since, the late Sir George Ballingall afforded me an opportunity of examining one or two of the numerous fine specimens of Dracunculi, which had, I believe, been preserved in his collection for a period of something like thirty years. The result of this examination (as shown by a statement published in the second edition of Ballingall's well-known "Outlines of Military Surgery") yielded a highly satisfactory confirmation of the views of Busk and Jacobson respecting the viviparous character of this worm. I found myriads of minute larval Dracunculi, in various stages of development, within the maternal body, the latter appearing to be little else than a long, double, cylindrical sac, filled almost from one end to the other. Respecting other points connected with our knowledge of the history and ravages of the Dracunculus we stand indebted to the contributions of numerous writers, amongst whom, without placing them in any precise order, I may particularize the names of Agatharchidas, Galen, Velschius, Kaempfer, and Cartheuser, Blömmers, Lister, Grundler, Gallandatus, Modeer, Linneus, Gmelin, Rudolphi, Olfers, Lamarck, Bruguière, Pruner, Gescheidt, Chiaje, Ferrari, Richeraud, Chapotin, Gand, Weihe, Oppenheim, Cuvier, Charvet, Marc and Laennec, Dubois, Leblond, Dampier, Bajon, Clot-Bey, Mongin and Blott, Dujardin, Brulatour, Maisonneuve, Robin, Thibaut and Benoit, Andry, Chardin, Moquin-Tandon, Davaine; also Ætius, Niebuhr, Paulus Ægineta, Rhazès, Avicenne, Albucasis, and other Arabic authors; also Cezilly, Loeffler, Eschricht, Oken, Dutschek, Fischer, Kunsenmüller, Creplin, Siebold, Küchenmeister, Weinland, Eberth, Williamson, Van Someran, Ewart, Grierson, Paton, Scott, Adam, Kennedy and Smyttan, McGrigor, Young and Jamieson, Minas and McKenzie, Clark, Heath, Forbes, Chisholm, Greenhow, Morehead, M'Clelland, Lorimer, Bird, Leith, Mitchell, Stewart, Duncan, G. Harley, and Aitken. To wade through the literature of Dracunculus, as presented by the combined writings of these and other unnamed authors, would almost occupy a life-time, supposing any single individual were qualified for the task. It is fortunate, indeed, that all the important points recorded by the more ancient authors have been carefully culled and handed down to us from time to time; so that, now, in the writings of Küchenmeister, Davaine, and Aitken alone, one may find all that is historically and professionally interesting, whilst in those of Busk, Carter, and Bastian, we are presented with the most satisfactory anatomical data yet on record.

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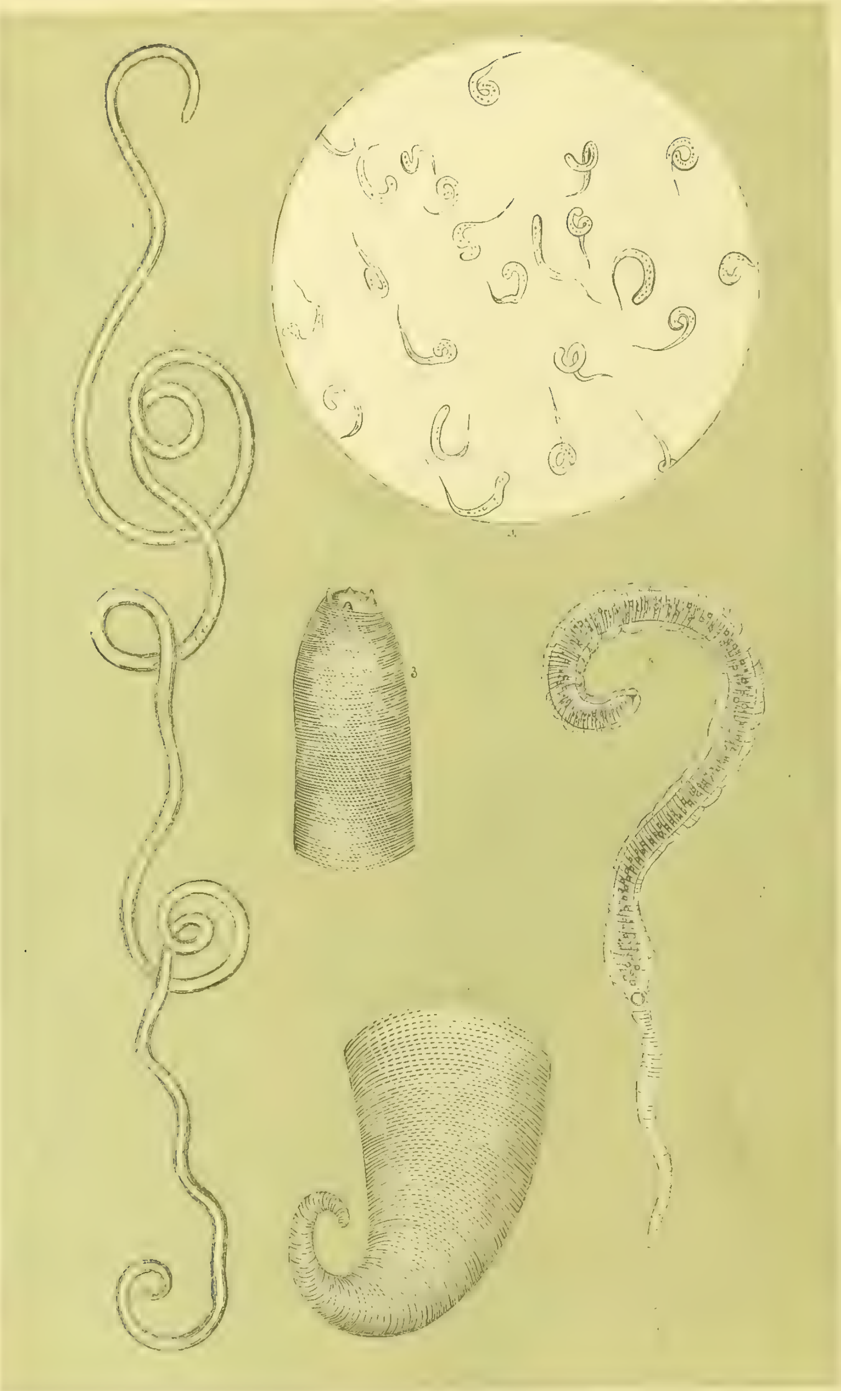

Dracunculus medinensis, Cobbold.

T. S. C., delt.

To give a brief outline of the subject, in its entirety, is the object of the following pages :—

30. Dracunculus medinensis.

Dracunculus, Lister ; Gallandatus ; Carter.
D. persarum, Kämpfer ; Diesing.
Filaria medinensis, Gmelin ; Olfers ; Rudolphi ; etc.
F. dracunculus, Bremser ; McClelland ; Pruner.
Furia medinensis, Modeer.
Gordius medinensis, Linneus ; Bruguière.
Vermis medinensis, Grundler.

General and Specific Characters.—A nematode helminth, the female only at present known, measuring from one to six, or even (according to Gallandatus) twelve feet in length, and about $\frac{1}{10}$ of an inch in thickness ; body uniformly cylindrical, terminating inferiorly in a more or less curved or reversed mucronate tail ; head somewhat truncate or flatly convex, with a central, simple, oral cavity, surrounded by four equidistant, crucially-disposed papillæ ; mode of reproduction viviparous, the numerous young invested by the uterine walls, almost filling up the entire cavity of the body.

If any man will abandon his preconceived notions, and take the trouble to read Küchenmeister's historical narrative of the Dracunculus (as it is given in Lankester's edition of the well-known "Manual of Parasites"), he will, I apprehend, find it very difficult to resist the conclusion that Moses was the first writer on this subject ; and further, he will be well nigh necessitated to believe that the "fiery serpents" which afflicted "the children of Israel during their stay in the neighbourhood of the Red Sea" were neither more nor less than specimens of our *Dracunculus medinensis.* At all events, if he doubt this, he will have little hesitation in believing that Plutarch describes the *Dracunculi,* when in the eighth book of his "Symposiacon" he quotes Agatharchidas as stating "that the people taken ill on the Red Sea suffered from many strange and unheard-of attacks, amongst other worms (from) little snakes, (*δρακόντια μίκρα*), which came out upon them, gnawed away their legs and arms, and when touched retracted, coiled themselves up in the muscles, and there gave rise to the most insupportable pains." Without affecting the sense, I have here purposely altered Küchenmeister's original record in a slight degree (" Parasiten," s. 305) in order to render the passage a little more euphonious to the English reader. Further into this part of the subject, however, it is needless to enter, especially since the Sydenham Society's publication is easy of access to all who desire to investigate the matter for themselves.

Distribution.—The Guinea-worm possesses a comparatively limited range, for not only is it proper to tropical regions of the globe, but within these intertropical limits it is almost exclusively confined to certain districts in Asia and Africa. Thus, according to Künsenmuller, as quoted by Busk, it occurs endemically in Arabia Petræa, on the borders of the Persian Gulf and Caspian Sea, on the banks of the Ganges, in Upper Egypt, Abyssinia, and the coast of Guinea. " In America, the Guinea-worm is unknown, except in persons who have had communication with Africa or other parts where it is indigenous. The island of Curaçoa is the only locality in the New World which offers an apparent exception to this fact; and it would be highly desirable to ascertain the real state of the case in this instance." The later observations of Chisholm, indeed, show that the Dracunculus is really prevalent in several of the West Indian islands, especially in Granada, or Grenada, as it is sometimes spelt. It is not impossible, therefore, that all the numerous islands lying near, as well as between Curaçoa and Grenada, may turn out to be Guinea-worm districts. Mr. Busk subsequently adds: " Though endemic only in the above-mentioned parts of the world, it would yet appear that all races of mankind are obnoxious to the attacks of the *Filaria* when exposed to what may be called the contagion, that is, when placed in circumstances under which it might be supposed a contagious *seminium* could be conveyed to them. This liability is incurred by the exposure of the bare surface of any part of the body to water in which the infection may be supposed to reside. There is, at all events, at present, no evidence of any other source of infection. I have known many instances tending to prove that in order that a European should become infected with the Guinea-worm on the coast of Africa, it is not necessary that he should have been on shore at all. It has been quite sufficient for him to have exposed the bare surface of some part of his person to the water in the native canoes alongside, or, it may be, to the discharge from the sores of those labouring under the disease. This mode of its introduction accounts for the frequency with which the legs and feet are attacked by the parasite in preference to other parts of the body, as it will always, I believe, be found that the men who have become so affected have been in the habit of going about with bare feet, as is common among sailors in warm latitudes. That the contagious material is conveyed in water is also further indicated by the well-known fact that in India, where it is the custom of the natives to carry water in skins on their backs, the worm makes its appearance on the back and shoulders, and upper part of the body." Nothing that has since been written has had the slightest tendency to contradict the above conclusions, which, in point of fact, are essentially correct. It would appear, also, that the Dracunculus gains access to the human body without reference to age or sex, race or country, the only necessary condition being that the skin be exposed to water in those localities where the Dracunculi flourish.

Even more cogent illustrations of the truth of this general statement may be gathered from a variety of sources, and especially from the recorded experience of eminent medical officers attached to our Indian armies. Those troops which have been most exposed during the rainy season have subsequently exhibited a more or less marked evidence of having been invaded by the Dracunculus; and as the period of incubation of the entozoon usually extends from twelve to fifteen months, it necessarily happens that the disease has frequently shown itself in localities far distant from the spot where the troops originally contracted the disorder. It has been said that the period of incubation of the worm is not less than a year, but Carter of Bombay mentions that in a school of fifty boys bathing in a certain pond whose muddy sediment swarmed with microscopic tank-worm (*Urobales palustris*, Carter), twenty-one were attacked with Dracunculus *during the year*, whilst the boys of other schools, bathing elsewhere in the island, were not infected with the exception of one or two individual instances here and there. This remarkable occurrence also points to the possibility of the young Dracunculi being occasionally confined to particular pools of water, or, at least, to the probability of their being much more abundant in some waters than others, although the whole locality may be harbouring them in greater or less abundance. Such a distribution is in unison with the general law affecting the variable prevalence of other animals in particular localities. A great deal has been written respecting the nature of the soil and other geological characters occurring in the Indian worm-districts; but the speculative views enunciated in reference to their connection with the prevalence of Dracunculus are, to my mind, little worthy of credit. However, those who think otherwise should consult the writings of Smyttan, Greenhow, Bird, Chisholm, Forbes, and others; and especially, also, the admirable *résumé* given by Aitken in the last edition of his work on "The Science and Practice of Medicine."

Structure.—If a full-grown *Dracunculus medinensis* be removed from the subcutaneous cellular tissue in its entirety, it is invariably found to exhibit the aspect of a uniform cylindrical worm, whose anterior and posterior extremities are only distinguishable from one another by the circumstance that the former is somewhat bluntly rounded off, whilst the latter is suddenly attenuated so as to form a short, filamentary caudal appendage. This so-called tail is most commonly curved and retroverted, but it is occasionally straight, under which condition it bears some resemblance to the terminal intromittent organ of a male *Strongylus*. I believe it was the occurrence of this rather unusual peculiarity in the caudal formation which led Owen to believe that he had stumbled upon a male *Dracunculus*, and which further induced him to figure the same in his well-known article "Entozoa" in "Todd's Cyclopedia."

Be that as it may, the above-mentioned characteristics come out more cogently when we submit the worm to microscopic investigation. Under low powers, the head displays a rather flatly-convex outline, near the centre of which four papillæ, or rudimentary tentacula, project at equidistant intervals from one another, and from the centrally-placed oral aperture. These spinules, as they have been termed, were described long ago by several authors, but not so accurately as has been done by Bastian, who observes that the two vertical papillæ are much larger than the others, and also nearer the oral aperture, "whilst the two lateral, more remote from the mouth, not prominent, and scarcely more than opaque spots, are situated at the commencement of the gradually-widening, lateral, intermuscular spaces." As my own examinations of Sir George Ballingall's specimens of Dracunculus were made many years ago, and as, with the exception of drawings of the young, I have no trustworthy record of my dissections, I shall on several points rely on Bastian's very careful description of the adult worm. The papillæ in question are situated, moreover, within the limits of a quadrangular space, from whose borders the four great longitudinal dorso-ventral muscles apparently take their origin. Respecting these muscles little need be said, since in all their essential features they correspond with those of other nematoda, and terminate in the so-called caudal appendage. As regards the integument, this consists of two distinct and easily-separable layers, an external thick, transparent, cuticular, chitinous investment, and an internal thin, granular layer. The external layer, according to Bastian, is itself separable into two portions, the outer being thick, "tough, elastic, transparent, and perfectly structureless, save that it presents transverse markings at intervals." The surface itself is perfectly smooth, "there being no appreciable depressions corresponding to the annulose markings such as may be seen to a slight extent in *Ascaris lumbricoides* and *A. mystax*, but there is some considerable alteration in the refractive power of the membrane in these situations, as when seen a little beyond the proper focal distance these markings become most distinct, appearing as bright, white lines. The internal portion is composed of three different sets of very delicate lamellæ, each being transparent, glass-like, and structureless, with the exception of certain faint, rectilinear markings at regular intervals." Bastian considers these markings illusive, and due to some structural peculiarity, involving an alteration of the refractive properties of the lamellæ. The simple, delicate, internal, homogeneous, granular layer is not recognized by Bastian, but it is, probably, the original source of all the secretion thrown out to form the complicated external chitinous layer. The digestive apparatus is exceedingly simple. It consists of a cylindrical tube extending from the mouth to the concavity of the tail, in which latter situation the anal orifice is imperceptible. Bastian says that the intestinal canal winds itself several times round the genital tube, is of nearly uniform size throughout its whole extent, and is twice or three times as broad as the œsophagus. Respecting the reproductive organs, I have already had occasion to remark upon the extraordinary development of the uterus, which, with its highly-developed embryonic contents, occupies almost the entire cavity of the Dracunculus. Many authors, indeed, have overlooked the very existence of any ovarian or uterine tube in consequence of its intimate union with the parenchymatous (Marksubstanz), muscular, and internal integumentary layers. A little care, however, enables us to separate these parts from one another, and, at least, to recognize the walls of the uterine cavity. Sometimes the uterus, when not over-distended with embryos, lies comparatively loose; at least, I found this to be the case in one of the specimens preserved in the Museum of the Middlesex Hospital. According to Bastian, " the genital apparatus consists of a large highly-organized sac or uterus, distended with young *Filaria*, and a little fine granular matter. It occupied the whole of the peritoneal cavity in the specimens examined (by him), except from one to two and a-half inches from the anterior extremity and about a quarter of an inch or less from the tail. Both anteriorly and posteriorly this large sac terminates abruptly in a small tube twisted several times round the intestine, or forming a knotted, glandular-looking mass. Each tube is about one inch in length, and the two are in every way alike. In common with other observers," he adds, "I have been unable to discover any vulva or vagina; but the symmetrical formation of the two extremities of the genital tube leads me to believe that the genital aperture, if it does exist, must be situated a short distance behind the middle of the body; regarding the two terminal tubes as ovaries, and the large sac as a double oviduct or uterus, which by its enormous development appears to form one great tube, and which has obliterated the vagina." It is quite clear from this, and from the independent observations of Busk, Carter, and myself, that the young can only make their eventual escape by the breaking up of the parent's body. This was long ago insisted on by Busk, but it is not, therefore, necessary to believe with Carter, that they escape "through a rupture of the integuments near the mouth," or, indeed, at any other particular spot. In all probability, as also, apparently, obtains in *Sclerostoma syngamus*, the young escape in consequence of the rupture of the maternal body at any part, either before or after its decomposition, and escape from the "bearer" or "host." Probably, the necessity of observing a rule (respecting the burning of the worms) which I have insisted upon elsewhere has never been thought of, and thus even those who have been instrumental in relieving their fellow-creatures by the ordinary methods of cure, have, by casting aside the adult worms, whole or piecemeal, contributed unwittingly to the subsequent propagation of the disease. Finally, as regards the existence of the nervous and water-vascular systems, Bastian speaks somewhat confidently. He speaks of "two delicate ganglionated cords, extending the whole length of the worm, one occupying the centre of each lateral intermuscular space." If these, as I understand him to represent, are distinct from the ordinary lines traversing the centre of the lateral longitudinal space, then I think it must be allowed that he has satisfactorily settled this point; and I can, therefore, have no hesitation in agreeing with him that the four remaining equidistant, longitudinal vessels so readily visible under low magnifying powers, are, in their turn, referable to the so-called water-vascular system.

Development.—The discovery of the viviparous mode of reproduction in Dracunculus is, I believe, due to Jacobson, yet it is only within comparatively recent times that the importance of this discovery has been fairly recognized. The structure of the young has been ably investigated by Carter, Busk, Robin, Moquin-Tandon, and others, and I had myself long ago detected certain anatomical peculiarities respecting the precise nature of which we are still in doubt. It remained for Bastian to clear up several of the missing links in the chain of anatomical evidence, but by far the greater number of the more needful facts in reference to the life-history of our parasite are still concealed from view. Bastian, indeed, advances a number of theoretical notions on this score, but I fear they are little worthy of credit and, certainly, they are totally opposed to what we know of the ordinary developmental processes as they occur in nematodes generally; in other respects, however, his statements are both valuable and thoroughly trustworthy. Bastian having carefully reviewed the writings of Busk, Owen, Jacobson, and others, seems to have supposed that the greatly-developed uterine organs had been altogether overlooked before his time. For my part, I can only say that ten years ago I distinctly recognized these organs as nearly filling up the general cavity of the body of Dracunculus, and, shortly after my investigations, Sir George Ballingall of Edinburgh, in the second edition of his well-known work on "Military Surgery," expressly recorded the fact in the following terms:—"The assistant-conservator of the Anatomical Museum in our University has detected *in the oviduct* of an adult specimen from my collection, myriads of minute and perfectly-developed (embryonic) Dracunculi. They can be very well seen with an half-inch object-glass, but their structure is best exhibited if the magnifying power be increased to two hundred and fifty diameters linear." These observations were, I believe, made during the winter of 1853-54. In July, 1854, M. Robin made a similar statement shortly after his examination of a fresh *Dracunculus* which had been extracted from the leg of a man by M. Malgaigne. Robin, not unsuitably, compared the worm to a double tube, one tubular sheath, as it were, enclosing the other. "The second tube," he distinctly affirms, "*is the oviduct, or, rather, that part which represents the uterus.* The young still remaining in the uterus were nearly all coiled, sometimes with the tail sallying outwards, at others rolled like the rest of the body." I have thought it only due to Robin and myself to show that we, at least, whatever our shortcomings, were ten years ago, from our own personal observations, made perfectly aware of the "great development of the genital tube, and its close adherence to the parietes of the body." Respecting the full-sized young Dracunculi our observations, as well as those of Carter and Busk, have exhibited several discrepancies, some of which have been satisfactorily accounted for by the excellent descriptions of Bastian. Thus, in regard to their structure, most of us agreed in recognizing a slightly-trilobed or tri-papillated mouth; but Carter failed to demonstrate the existence of these tubercules, and spoke of the oral aperture as being simple or "punctiform." The body throughout its three upper fourths appeared to me to be cylindrical, but Robin found that it was flattened; it is finely striated transversely, except at the part where it rapidly contracts to form the slender, sharply-pointed tail. According to Carter, Robin, and Davaine, the young attain a length of about $\frac{1}{33}$ of an inch, but Bastian gives it as about $\frac{1}{42}''$. In thickness, Carter gives the approximative diameter as $\frac{1}{633}''$, Robin makes it $\frac{1}{990}''$ to $\frac{1}{1320}''$, whilst Bastian gives their breadth at $\frac{1}{1428}''$, and Davaine $\frac{1}{2500}''$. I make their greatest length and breadth to be $\frac{1}{30}''$ by $\frac{1}{1000}''$. Robin, Moquin-Tandon, and myself thought we recognized a distinct, rounded, anal orifice; and whilst Busk, on the one hand, saw nothing which in the slightest degree indicated the presence of an anal opening, Carter, on the other hand, described the structure which we called the anus as a gland, at the same time placing the alimentary outlet on one side and a little above it. Bastian, however, if his demonstrations are correct, proves us all to be somewhat in the wrong. According to Bastian, "the intestinal tube is about $\frac{1}{87}''$ in length, and appears to consist of a simple canal of varying calibre, pursuing a nearly straight course, and terminating cœcally at about the middle, in length, of the worm." He, like Robin, recognized distinct œsophageal and stomachal divisions, and in a few examples Bastian observed the

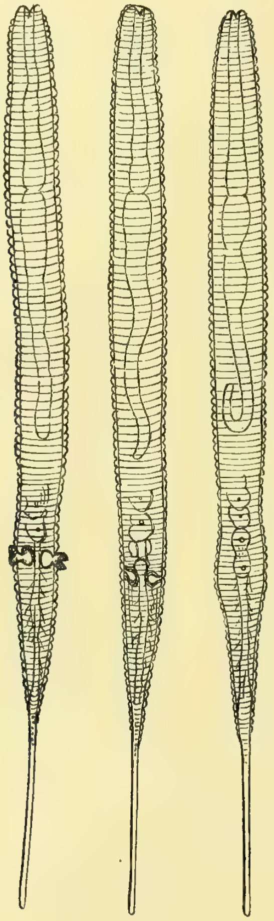

FIG. 80.—Three representations of the fully developed embryo of Dracunculus, showing the so-called "lateral sacculi," and, more particularly, the mode in which the intestine terminates (× 500 diam.)—Bastian.

cœcal or terminal portion of the intestine to be partially reflected upon itself. In regard to the circular opening which Robin and myself described as the anus, Bastian says there is a rounded body "about $\frac{1}{2200}''$ in diameter, with a dark or light spot in the centre, according to the varying focal distance, and which seems to represent a central aperture. Sometimes, above this, traces of two or three large cells may be recognized, whilst, behind, nothing definite can be made out, save that the cavity of the body is visible for about $\frac{1}{400}''$. In other specimens of the young worm the central body and spot are wanting, but, in its stead, two lateral sacculi are met with, about $\frac{1}{3300}''$ in diameter, that communicate with the exterior by a minute channel through the integuments, which can sometimes be distinctly recognized. At other times the channel is obscured by protrusion, which appears to have taken place through it, of a minute bilobed papilla, projecting $\frac{1}{10000}''$ from the side of the body. When the projections are seen, the sacculi are indistinct." It were a waste of time to enter into speculations in reference to these minute organs, the nature of which will, doubtless, by and by, be thoroughly investigated. As Bastian found the young in all stages of development, from the germ condition $\frac{1}{5000}''$ in diameter up to perfect embryo, and as, moreover, he, like others long before him, could detect no sexual orifice in the adult Dracunculus, he has even stated his belief that the young are produced by a non-sexual process of development, and consequently, also, calls these germs "pseudova." I cannot, of course, for obvious reasons, share in this opinion; and I must now, moreover, quit this portion of my subject, hoping to be able in my concluding summary to introduce a number of interesting facts and surmises, for the details of which I cannot, in consonance with the scope and object of this work, here find sufficient space.

Treatment.—Every Oriental traveller is more or less familiar with the time-honoured methods employed in the process of extracting the adult Guinea-worm. Volumes, as we have seen, have been written on all the more important practical bearings of this subject, and many of the ancient works have been illustrated with elaborate figures showing the worms *in sitû.* Amongst the most remarkable of these is that of G. H. Velschius, in the perusal of which we are amused, if not edified, by the numerous plates representing the old Persian surgeons extracting the Dracunculus.* The plan followed of old is essentially the same as the one most successfully employed at the present day. In all cases it has been found that the most satisfactory treatment consists in extracting the worm slowly by gentle traction. This is done by winding the exposed or protruding end of the parasite round a small stick of ivory, bone, or wood, or even round a portion of adhesive plaster, cardboard, or stout paper. The great thing to be avoided is the rupture of the worm, which, if it only once takes place, is extremely liable to produce serious inflammatory action in the infected parts. From this condition there usually follows a considerable amount of irritative fever, which is subsequently aggravated by the formation of abscesses, fistulous sinuses, and more or less extensive gangrene. Under these circumstances, therefore, even death itself may sometimes supervene. In certain cases, it has been observed that the worm exhibits a tendency to migrate from one part of the body to the other. Aitken quotes one or two remarkable instances of this kind from the "Indian Annals." Their direction of movement in the body is usually, if not invariably, from above downwards. Dr. Stewart gives the case of an officer who suffered for a period of three months from a Dracunculus, originally occupying the thigh, but which, in the space of a few days, passed down to the deep muscles of the foot, giving rise to violent inflammation and many abscesses. It is also stated that Dr. Ewert had seen a worm "change its position from the upper part of the lateral aspect of the thorax to the groin in the course of twenty-four hours." In similar cases, therefore, whenever the worm appears to be superficially situated, it would not be unreasonable to cut down upon the wanderer and arrest his progress, particularly if there seemed to be any marked external vesicles or elevations of the integument. Speaking prophylactically, all persons travelling in Guinea-worm districts, should be careful to protect their feet and legs during the rainy season, and especially also should they be scrupulously careful, after washing or bathing, to wipe themselves thoroughly dry—if possible, with warm or hot towels. In this way only can they be tolerably sure of preventing the incompletely-developed, but probably sexually-mature female Dracunculi from gaining access to their bodies.

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* "Georgius Hieronymus Velschius.—Exercitationes de Vena Medinensi, et de Vermiculis Capillaribus Infantium." Augsburgh, 1674.

Summary.—After a careful survey of all the more prominent facts and phenomena connected with the life-history, development, and propagation of the Guinea-worm, I offer the following conclusions :—

1. The Guinea-worm, as commonly known, is the adult female condition of a nematode parasite, forming a distinct generic type for which the title of *Dracunculus* ought still to be retained.

2. The female Dracunculus is parasitic only during the final stages of its life-period, after it has taken up its residence in the subcutaneous and intermuscular cellular tissues of man, dogs, and horses.

3. The adult female reproduces viviparously; and, in consequence of an enormous development of the internal reproductive organs, contains myriads of embryos in all stages of development.

4. The embryos, when set free, are capable of sustaining an independent existence; their vitality is so tenacious that, after a more or less complete desiccation, they will revive on the application of moisture.

5. The proper habitat of the free active embryos may be either the fresh water of natural stagnant pools, the damp mould and mud of low-lying marshy districts, or especially, the soft, ochreous, argillaceous clayey soil forming the bottom of wells, tanks, and other artificial reservoirs.

6. The male sexually-mature Dracunculus is at present unknown; in all probability it is very much smaller than the female, non-parasitic as far as animal bearers are concerned, and a *constant* inhabitant of fresh water, mud, and moist earth.

7. In all likelihood the male Dracunculus bears a close resemblance to *Urobales palustris*, or to some other of the numerous allied microscopic forms of Filariæ, which abound in the natural and artificial water-reservoirs above mentioned.

8. The young Dracunculi probably acquire sexual-maturity shortly after their escape from the parent; the sexes associating in muddy waters during the monsoon, after which period the males, in all likelihood, rapidly perish, the females being left to watch their opportunity for further development by migration into the human body.

9. The impregnated females do not gain access to their bearers by the mouth or stomach of the latter; on the contrary, there is every reason to believe that they enter the body in a direct manner, probably by penetrating the sudorific ducts of the skin.

10. Within the tissues of the bearer they grow with considerable rapidity, and in about twelve months, more or less, give rise to a formidable entozootic disease (*dracontiasis*) which, after prolonged monsoons, is not unfrequently severely endemic.

31. Dracunculus Loa.

Dracunculus Loa, Cobbold.
D. oculi, Diesing.
Loa, Guyot; Bajon; Mongin; Guyon; etc.
Filaria medinensis, Gmelin.
F. lacrymalis, Dubini.
F. oculi, Gervais and Van Beneden; Moquin-Tandon.

Before I became acquainted with Diesing's recent determination to separate this worm from the little group of eye-nematodes already described under the heading of *Filaria lentis*, I had independently arrived at the conviction that the *Loa* was a totally distinct worm from the *Filaria oculi*, described by Nordmann, Von Ammon, Owen, and others. I follow Diesing, in placing this worm in the genus Dracunculus, whilst I provisionally retain the native name *Loa* for the specific title, as being more distinctive than the one proposed by Diesing. Under the title of *Filaria oculi*, Moquin-Tandon (in his "Zoologie Médicale") speaks of certain minute Filariæ as "not uncommon in the negroes of the Angola Coast;" and he gives other localities where it occurs. These worms are identical with those described by Guyot as dwelling beneath the conjunctiva of negroes at Congo and in the Gaboon region generally. The parasite in question is rather more than an inch in length; it is, we are told, termed *Loa* by the natives, who also state that after a period of several years the worm voluntarily quits the organ, and thus the disease becomes naturally cured. This parasite, indeed, appears to enjoy a tolerably wide geographical distribution, as it has been observed by Clot-Bey in a negress who had come from the town of Monpox, situated on the banks of the river Magdalena; by Sigaud, who saw one in the eye of a negress in Brazil: by Blot at Martinique, who saw two in a negress originally from Guinea; by Bajon, who met with one in a little negro girl who had come from Guadeloupe; by Mongin, who found one in a negress who had been living in the Island of San Domingo; and by Lestrille, who removed one from beneath the conjunctiva of a negro, who came from Gaboon. Those who desire to look further into the subject should consult Davaine's treatise, where they will find all the above-mentioned cases more or less fully reported, together with several important extracts from the writings of the eminent surgeon Guyot, who made several voyages to the coast of Angola, and paid special attention to the eye-diseases produced by this parasite.

PART III.

SPURIOUS HELMINTHOLOGY;

OR SOME ACCOUNT OF THE INTERNAL PARASITES OF MAN NOT BELONGING TO THE CLASS OF HELMINTHS, TOGETHER WITH NOTICES OF VARIOUS ANIMAL AND VEGETABLE SUBSTANCES REPUTED TO HAVE COME FROM THE HUMAN BODY.

SPURIOUS HELMINTHOLOGY.

CHAPTER I.

PENTASTOMA TÆNIOIDES.

General and specific characters of *Pentastoma tænioides*—Occurrence of this parasite in the human subject in its larval condition—Structure of the so-called *Pentastoma denticulatum*—How the eggs and embryos may gain access to our bodies—Pruner's discovery of a second species of human Pentastome—Its characters contrasted with those of the larva of *Pentastoma tænioides.*

As I propose to devote two brief chapters to the consideration of the Pseudelminths (taking the word in its widest sense), it is fortunate that the subject will naturally divide itself into two distinct sections. In the first division I place those Entozoa which are not referable to the class of Helminths (= Acanthotheca of Diesing); and in the second section I include all the Pseud-entozoa, whether they be merely misplaced worms, non-parasitic animals, or any kind of animal and vegetable substances or organisms which have been erroneously described as belonging to the class of Entozoa. One would naturally prefer to leave these out altogether; but since many persist in maintaining the helminthic character of all sorts of strange products; and since, moreover, it is necessary that the medical practitioner should be on his guard against imposition, I have thought it would render this work more useful and complete, if I gave an outline of this part of the subject, however short it might be necessary to make it. In the present chapter I shall treat of the first section of the pseudelminths, comprising only two separate species, which possess, however, very considerable interest alike for the naturalist and the pathologist.

1. PENTASTOMA TÆNIOIDES.

P. tænioides, Rudolphi; Bremser; Diesing; etc.
P. denticulatum, Rudolphi; Bremser; etc.
P. serratum, Rudolphi; Diesing; Miram; Dujardin.
P. emarginatum, Rudolphi.
P. settenii, Diesing.
P. zera, Creplin.
Linguatula tænioides, Lamarck; Cuvier; Owen; etc.
L. lanceolata, Blainville.
L. denticulata, Lamarck.
L. serrata, Froelich.
L. ferox, Küchenmeister.
Polystoma tænioides, Rudolphi.
P. denticulatum, Rudolphi.
P. serrata, Zeder; Rudolphi.
Tetragulus caviæ, Bosc; Kaufman.
Prionoderma lanceolata, Cuvier.
Echinorhynchus capræ, Braun.
Tænia lanceolata, Chaubert.
T. rhinaria, Pilger; Greve.
T. caprina, Abildgaard; Gmelin.
Halysis caprina, Zeder.
Monostoma settenii, Numan; Siebold.

General and Specific Characters.—An entozoon belonging to the family of Acaridæ, and having no structural connection with the true helminths; in the adult state characterized by the possession of a vermiform, lancet-shaped body, flattened at the ventral surface, attenuated posteriorly, and marked transversely by about ninety rings; cephalothoracic segments continuous with the body, supporting each a pair of strong retractile chitinous claws, these four feet or limbs being biserially disposed on either side of the middle line; head somewhat truncated or abruptly rounded, mouth broadly oval and armed with a horny lip; integuments perforated with numerous so-called respiratory openings or stigmata, which are, however, wanting in the cephalic segment: general surface smooth, but in the larval condition (= *Pentastoma denticulatum*) furnished with numerous rows of small, sharply-pointed spines; length of the female from three to four inches, with a breadth extending to nearly half an inch; length of the male only from eight to ten lines, with an extreme breadth of one line and a half; genital aperture of the female at the extremity of the tail, that of the male being situated at the front part of the abdomen in the middle line; mode of reproduction oviparous, with a subsequent and complete metamorphosis.

In the sexually-mature condition this parasite infests the nostrils and frontal sinuses of the dog and wolf, and occasionally also, though very rarely, the same cavities of the horse and sheep. In the pupa and larva state it sometimes occurs in the abdominal and thoracic cavities of the human body; much more frequently in various herbivorous mammals, such as the sheep, deer, antelope, peccary, porcupine, Guinea-pig, hare, and rat; and, according to Creplin, it has also occurred in the domestic cat. In these animals and in man the so-called *Pentastoma denticulatum* usually occupies little cysts within or upon the peripheral parts of the liver and lungs, but I have occasionally found them free in the cavities of the abdomen and pleura.

The anatomical investigations of Blanchard, Van Beneden, and T. D. Schubert, have incontestably shown that the Pentastomata have little or nothing in common with the Cestoda, in which order of helminths they were formerly classed; but that, on the contrary, these parasites belong either to the Acarine or Lernæan Arthropoda. They constitute, in short, a genus which may be regarded as osculant between the Acaridæ and Lernæadæ, leaning, perhaps, more strongly to the former, in which family I have accordingly placed them. Leuckart, who has written a profound memoir on the Pentastomes,* elevates them into a distinct family, comprising one genus of eighteen species. Here, however, I have no space to follow him either into minute anatomical details, or into the various interesting questions which a consideration of the metamorphoses and affinities of the Pentastomata naturally suggests. Still less can

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* "Bau und Entwicklungsgeschichte der Pentastomen; nach untersuchungen besonders von *P. tænioides* und *P. denticulatum*." Leipzig and Heidelberg, 1860.

I recapitulate the experimental *data* by which he has satisfactorily proved that the *Pentastoma denticulatum* is merely the larval or sexually-immature condition of *Pentastoma tœnioides*. My own few experiments on this score were only attended with negative results; but Leuckart's testimony is conclusive. I have already, indeed, in the pages of the "Microscopical Journal" (Vol. vii. p. 182), given an abstract of one of his earlier papers on this subject, and therefore I need here only adduce such of the results as seem necessary to throw light upon the general features of this parasite and the metamorphoses which it undergoes. To be brief, Leuckart recognizes four well-marked stages of development. First, the embryo with a boring apparatus. Schubert correctly described it also as having two pairs of lateral appendages or feet, each of these being supplied with two claws; it has likewise a caudal prolongation nearly equal in length to the rest of the body. Van Beneden gives a very similar description (Bull. de l'Acad. Royal de Belg., xv., 1848), and, from my own examinations, I can offer similar testimony. The second stage is that in which the embryo has become transformed into a motionless pupa. The third is the ordinary larval condition (= *Pentastoma denticulatum*) characterized by numerous rows of small tooth-like spines in addition to two pairs of double claws. The fourth is the sexually-developed stage, furnished with a simple hook-apparatus, and unsupplied with integumentary denticles. "Our Pentastomes, therefore," says Leuckart, "exhibit two kinds of larval forms, an earlier and later one, as takes place in other animals; this also occurs even in insects (*Strepsiptera* and *Meloidæ*); only that, in our case (*i.e.* in *Pentastoma*), both do not immediately follow one another, but are separated by a resting condition, which I have designated as the pupa stage. In choosing this name I do not mean to express a complete identity of this intermediate state with the pupal sleep of insects."

As it is only the encysted and larval conditions that are to be met with in the human body, I now proceed to notice these more

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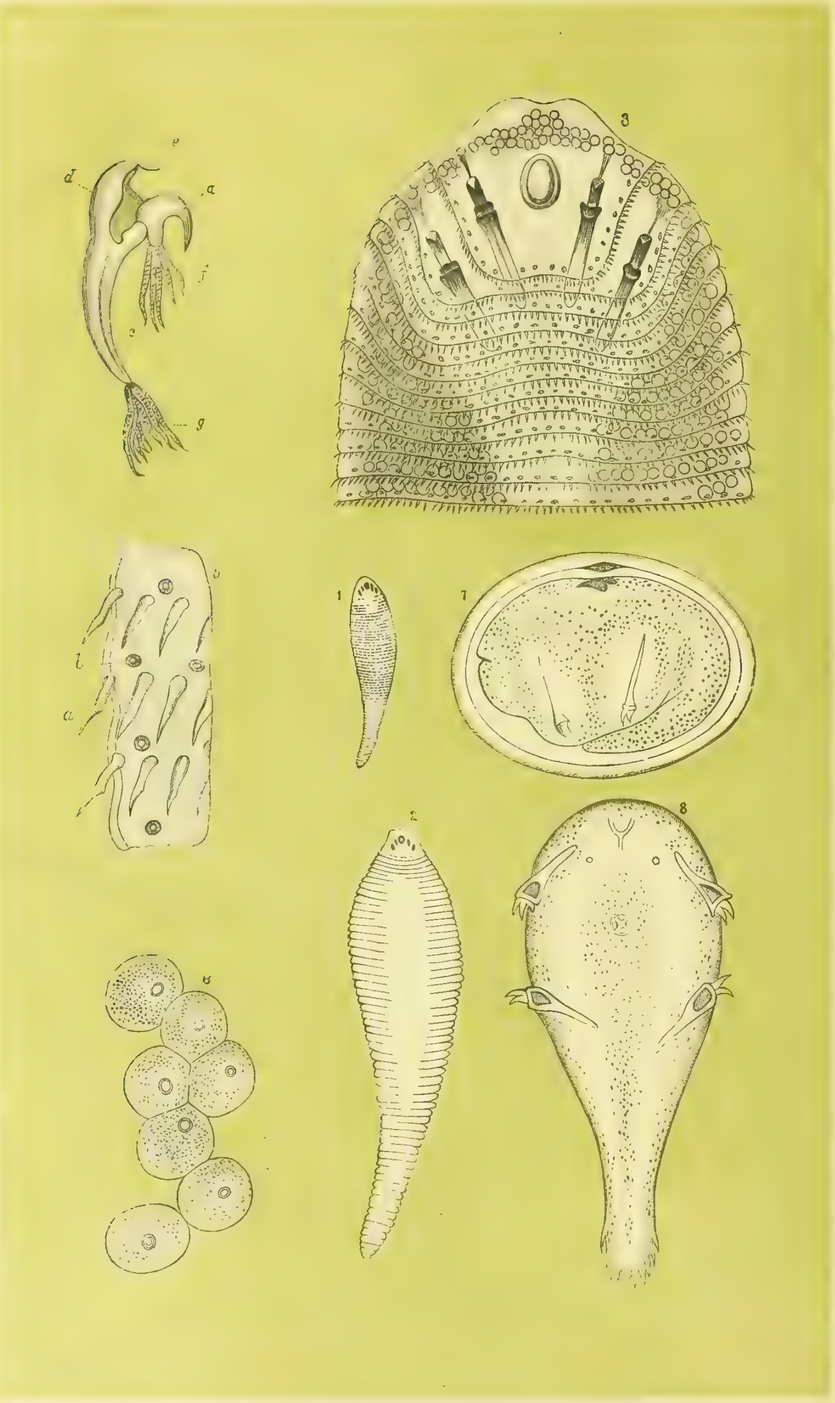
PLATE XXI.



Pentastoma tænioides Rudolph.

(Partly from Leuckart.)

T. S. C., delt.

in detail. So far as my own observation extends, the pupa, in its later stages, closely resembles the free larva, but, as Leuckart's researches show, the earlier stages are very different. The embryo, after encystation, repeatedly casts its skin, and during the intervals of these several successive moultings, the young animal makes rapid growth, accompanied by a series of striking structural changes. Passing through these it, at length, acquires the perfected larval state, or that known as the *Pentastoma denticulatum.* This stage has been described by numerous observers, but, in order to save space, I shall content myself with reproducing the facts which I have myself observed and recorded elsewhere.*

On the 10th of February, 1859, I obtained numerous examples from the viscera of a Bubale (*Antilope bubalis*, Pallas), which had died the day previous at the Zoological Society's Gardens. The greater part of these worms occupied the surface of the lungs and intestines; a considerable number, however, being enclosed in cysts beneath the pulmonary pleura. Fifteen or more having been taken away for the purposes of microscopic examination and experiment, I had ample opportunity of watching the movements of the cephalic claws whilst the animals were still living. I may here remark, that these claws do not in any way resemble those of the tapeworm family, but, in strict accordance with other external features, show that the Pentastomes belong to an entirely different type. Placed under the half-inch objective, with the ventral surface uppermost, the transparency of the body permits a full view of the apparatus of hooks, as displayed in the accompanying drawing (Pl. XXI., Fig. 3). It will be noticed that the points of the claws are directed towards the observer, and not towards the longitudinal axis of the body, as Küchenmeister's figure ("Parasiten," Table VIII., fig. 11) would lead one to suppose; moreover, the claws are placed obliquely in reference to the central line, the angle of divergence being about 25°. During the eversion and retractation of the claws, the vacant spaces directly above them dilate and contract, so as greatly to facilitate the prehensile action of the hooks. These depressions are obviously inversions of the ventral integument, forming socket-like pouches for the implantation of the hook-capsules. If one of the claws be isolated and viewed laterally, it will be seen to consist of two parts—namely, a strongly-curved *hook* (*a*, fig. 4), and a *capsule* (*b*). The upper part of the latter forms a hood (*d*), for the lodgement, support, and protection of the hook; the lower tubular portion serving to fix the apparatus in the body, and at the same time to regulate the movements of the claw through the intervention of a muscular pulley (*g*), which enters the tube at the lower end. Acting antagonistically to this, we find an extensor muscle (*f*) inserted into the anterior border of the base of the hook itself. The summit or projecting point of the hood (*Spitzendecker* of Küchenmeister) is flattened out, so as to form a three-cornered process (*e*), which covers and protects the sharp extremity of the hook when the latter is retracted.

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* "Linnean Society's Transactions," Vol. xxiii., p. 350.

In regard to other external appearances, my observations, for the most part, correspond with those already on record; but with reference to the rows of minute integumentary spines, it will be seen from my drawing, that the uppermost row is placed somewhat more apart from the second—at least, at the sides; the whole forming a complete and graceful tracing, as it passes downwards on either side between the inferior and superior pair of cephalic claws. Further, I do not find the spines themselves to be simply conical, as hitherto represented, because their uniformity of outline is interrupted at the lower third (as shown at the left margin of figure 5); this appearance, indeed, can only be seen by a lateral view. The so-called stigmata (*Athemlöcher* of Nordmann) display a double outline, but no vessels could be traced in connection with them.

With respect to the internal structure of this parasite very little can be made out, a circumstance which in itself favours the notion that we have to deal with an imperfectly-developed animal. From one end of the body to the other there exists a central clear space, and this is well defined by dark lateral masses, which narrow out on either side of the head, in the form of a horseshoe-shaped band enclosing the mouth and the four chitinous foot claws. These dark patches, at first sight, look like vitelligene organs, but a closer examination shows that they are entirely made up of large parenchymatous cells, unconnected by any special fibres or tubes. In an isolated and highly-magnified group of them, their granular contents and central nuclei were at once rendered visible (as shown in Plate XXI., Fig. 6), but some had become flattened at the sides from pressure, and exhibited an angular outline.

In regard to the occurrence of this parasite in the human body, I think it may be said that no one in this country has yet met with it. My colleague, Dr. Murchison, during the time he held the office of Pathologist at the Middlesex Hospital, diligently sought for it without success; nevertheless, it appears that the worm is not uncommon in the human subject in other parts of Europe and elsewhere. The best record which has been published on this head, is that given by Frerichs. In his excellent "Clinical Treatise on Diseases of the Liver," he writes as follows:*—"The Pentastoma is a parasite which has only recently been discovered in the human subject, but it is, nevertheless, far more common in the human liver than the Echinococcus. It is devoid of chemical importance, because it does not give rise to any functional derangements. Pruner ('Krankheit des Orients,' 1847, s. 245) was the first who pointed out the existence of the Pentastoma in the human liver. On two occasions he found an encysted parasite in the liver of negroes at Cairo, the nature of which, however, he did not accurately determine. Bilharz and Von Siebold ('Zeitschrift fur Wissensch. Zoologie,' Bd. iv., s. 63) recognized in it a new variety of Pentastoma, to which they gave the name of *P. constrictum.* In

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* New Sydenham Society's Edition, London, 1861. Translated by Dr. Murchison. Vol. ii., p. 276.

Germany the Pentastoma was found in the human liver by Zenker (' Zeitschrift f. ration. Medic.,' 1854, Bd. v., s. 224); it occurs, however, not only in this gland, but also in the kidneys, and in the submucous tissue of the small intestine (Wagner). The parasite is by no means rare with us. Zenker, at Dresden, succeeded in finding it 9 times out of 168 autopsies; Heschl, at Vienna, met with it 5 times out of 20 autopsies; Wagner, at Leipsig, once in 10. According to Virchow, it is more common in Berlin than in Central Germany. During six months at Breslau, I met with it in 5 out of 47 dead bodies. The Pentastoma endemic in Germany is not identical with that which occurs in Egypt; the former is the *P. denticulatum* of Rudolphi." This clear statement of Frerichs is extremely valuable; but, as Murchison has also pointed out, there is some discrepancy between Frerichs' and Küchenmeister's record of Zenker's experience. According to Küchenmeister, the distinguished Dresden physician met with the Pentastoma 30 times in 200 autopsies. At all events, in the face of these facts, it is, certainly, not a little singular that no one has yet detected it, as a human parasite, in this country.

In conclusion, I need only remark that although this parasite seems to cause little inconvenience to those of our race who harbour it, yet it may be as well to adopt precautionary measures in order to prevent its invasion of our bodies. Indeed, it is quite possible that it may be found to give rise to unpleasant symptoms when present in large numbers. As the sexually-mature Pentastome inhabits the nasal cavity of dogs and other domesticated animals, it is quite evident that the eggs of these worms will be scattered here and there whenever the "bearers" sneeze, or have a "running at the nose." In this way some of the eggs, with their contained embryos, may be directly transported to our persons, and even gain access to our mouths; but, it is more probable, that they are ordinarily introduced into our stomachs along with uncooked vegetable food or fruits, to which they will naturally adhere after expulsion from the animal's nostrils. The slimy nasal mucus secures this attachment, especially when it has become dry by exposure to the air. On reaching the stomach the embryos will escape from the egg-coverings and bore their way directly to the liver and other viscera, in which organs they become encysted and undergo the pupal transformation. Eventually they may acquire a length of two to two and a half lines, and at this stage they constitute the true larval form (*Pentastoma denticulatum*). After a while, the capsules enclosing them undergo calcareous degeneration, the parasite itself subsequently perishing. In the case of dogs, it is easy to perceive that when they are engaged in devouring the flesh of herbivora, the liberated larvæ will often come in direct contact with their noses. In this way, a few contractions of the body of the worm, aided by its foot-claws and integumentary denticles, will readily secure its entrance into the nasal frontal cavities. For our own security, therefore, we should avoid close contact with all dogs which frequent butchers' shops and knackeries, and especially, also, be sure that our market-garden fruit and vegetables be duly washed and cleaned before they are brought to table.

2. PENTASTOMA CONSTRICTUM.

P. constrictum, Von Siebold; Bilharz; Leuckart.
Linguatula constricta, ? Küchenmeister.
Nematoideum hominis, Pruner; Diesing.

As already hinted, by the quotation I have given above, from Frerichs, there is good ground for believing that at least two species of Pentastoma infest the human body. This second species, however, is at present only known to us in an immature condition, unless, indeed, as is by no means improbable, we are acquainted with the adult worm under some other name. It was first discovered by Pruner on two occasions in negroes, and he also subsequently found two specimens of the worm preserved in the Pathological Museum at Bologna, which had been removed from the human liver. Pruner also found it in the giraffe. Bilharz has since repeatedly detected this parasite in the livers of negroes at Cairo; himself and Von Siebold having made it the subject of careful study. All that need here be said concerning it may be summed up in a very few words:—It differs from the larval form of *Pentastoma tœnioides* (*i.e.* from the so-called *P. denticulatum*) in not being furnished with any integumentary armature of spines, and in the additional circumstance of its being a much larger worm. The cephalo-thorax is well marked, furnished with four foot-claws, and distinct from the elongated abdomen, which displays twenty-three rings or constrictions at tolerably regular intervals. The anterior extremity of the animal is rather obtusely rounded off, the caudal end being bluntly conical. It attains a length of rather more than half an inch, whilst the breadth scarcely exceeds a single line.

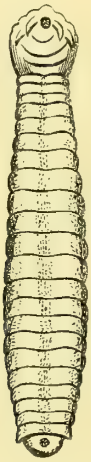

FIG. 81.—The *Pentastoma constrictum*. (Magnified four diameters.)—Bilharz.

CHAPTER II.

DACTYLIUS ACULEATUS.

Probable identity of *Dactylius aculeatus* with *Enchytræus albidus*—The so-called *Spiroptera hominis* referable to *Filaria piscium*—The *Diplosoma crenatum* or *concrementa lymphatica* artificially prepared from the ovisacs of the cod and haddock—*Gordius aquaticus* not a human helminth—Other spurious parasites—Various foreign bodies mistaken for Entozoa—Hope's list of insects and their larvæ reputed to have come from the human body—Bots received from Dr. Kirk.

I HERE undertake, in the first place, to consider very briefly those so-called worms, or pseudelminths, which cannot, in any legitimate sense, be recorded as human parasites. Some of them, it is true, are positively stated to have come from the human body, along with its natural excrementa; but we have abundant evidence to prove, at least, in many instances, that this could not have been the case. In this same category I shall include various miscellaneous substances which do not even belong to the animal kingdom. In the second and last place I shall add a list of those "bots" and other insect larvæ, many of which have undoubtedly become parasitic within the human body, whilst others of them have, as it were, gained accidental admittance into the intestinal canal. Not a few, apparently, have been purposely added to the excrementa with a view to deception.

1. DACTYLIUS ACULEATUS.

D. aculeatus, Curling.
Enchytræus albidus, Henle.

Naïs, Von Siebold.
Chætogaster, Von Baer.

There cannot be the slightest doubt in the mind of any well-informed naturalist, that Curling's *Dactylius* is neither more nor less than a species of abranchiate, setigerous annelid, specimens of which had been designedly introduced into the urine with the view of puzzling the medical attendant. The case is recorded in the 22nd Vol. of the "Medico-Chirurgical Transactions." The patient was a girl five years old, under the care of Mr. Drake. The memoir states that "some small worms were first observed in the urine," on the 26th of May, 1839, "and for several succeeding

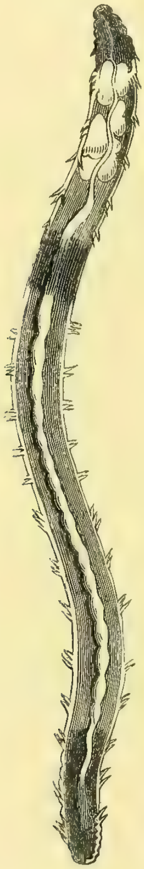

FIG. 82.—The so-called *Dactylius aculeatus*. (Highly magnified.)—Curling.

days, on rising in the morning, she voided from the urethra seven or eight." At all events, the worms received by Curling were subjected to a most rigid examination, as proved by the exceedingly minute and accurate description he has given of them. It is needless to give full details of the worm, but an abstract of his description, as abridged by Dr. Beale, may prove useful :—"The female was four-fifths, and the male only two-fifths of an inch in length. The tegument was armed with spines, occurring in clusters. The worms exhibited active movements, and when left in the urine they lived for two or three days. There were no symptoms in the case pointing to any derangement of the urinary organs." For my own part, I believe this spurious parasite to be identical with Henle's *Enchytræus albidus*, which is a small whitish-coloured annelid, not uncommon in our gardens, and particularly liable to take up its residence in the soil of flower-pots.* Its mode of migration from the flower-pot to the chamber-pot is not very difficult of explanation, even although Mr. Drake may not have had reason to entertain the slightest suspicion that he was being imposed on. Curling's specimens have a more considerable length than is usually obtained by the *Enchytræus albidus*, and this has led some to suppose that the species is distinct. I think I have seen specimens of *E. albidus* as long as the so-called Dactylius. It may be well to add that the genus Enchytræus is characterized by a rounded body, which is pointed in front and truncated posteriorly. The oral aperture is somewhat subterminal, and the annulations of the body each support four bundles of uncinate setæ or spines, of which latter there are usually three to each fasciculus. Lastly, I may repeat that I cannot, from his description, share in Curling's opinion that "those conversant with the structure of the Entozoa will readily recognize a true nematoid" in the so-called *Dactylius aculeatus*. On the contrary, I agree with Von Siebold, Henle, Küchenmeister, and Weinland, that "the decided annulation of the body, the dorsal vessel, the peristaltic movement of the alimentary canal, and the chemical nature of the skin and entire body *which decomposed in alcohol*," are points satisfactorily indicating that we have here to deal with a true annelid. Such a conclusion, however, does not lessen the value of Curling's independent description, which, as might be expected from so distinguished an observer, is singularly clear and complete.

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* See Müller's "Archiv.," for 1837, s. 74, Table vi.

2. SPIROPTERA HOMINIS.

S. hominis, Rudolphi; Owen; Dujardin; etc.
S. Rudolphii, Delle Chiaje.
Strongylus gigas (young of), Bremser.
Filaria piscium, Rudolphi; Siebold; Schneider; etc.
Gordius marinus, Linneus.
Agamonema piscium, Diesing.

This so-called human helminth, like the above, has been shown to be referable to another worm; but in the present case we have really to deal with an entozoon which most certainly never takes up its residence in the human body. Some time ago, after becoming acquainted with the result of Schneider's examination of the Berlin specimens of the so-called *Spiroptera hominis*, I referred to the original description of the case (as given by Lawrence in the "Medico-Chirurgical Transactions"), and was at once struck with the resemblance of one of the figures with the well-known *Filaria piscium*; but, on far deeper grounds than that obtained by a mere comparison of external form and size, Schneider has proved, with certainty, that the *Spiroptera hominis* is neither more nor less than the exceedingly common nematode which abounds in the cod and haddock. Schneider's brief communication ("Archiv. für Anat. und Phys.," 1862, s. 275) has been translated by Mr. Busk, and published in the "Notes and Correspondence" of the "Microscopical Journal" (new series, vol. ii., p. 302; 1862). As the paper in question is highly instructive, I quote the greater part of it from the English version: "Specimens (of the *Spiroptera hominis*) having been forwarded by Mr. Barnet to Rudolphi, are still preserved in his collection now in the Zoological Museum at Berlin, and it is these specimens which have formed the subject of Dr. Schneider's observations. They are contained, as described by Rudolphi, in three bottles. When Dr. Schneider first looked at those contained in one of the bottles, they appeared to be well-known forms, and nothing more, in fact, than the very common *Filaria piscium* of authors; a name under which several species of asexual nematoid have been described, which are found in the abdominal cavity and among the muscles of several marine fishes. The specimens in this bottle were the commonest of all, as was proved by a number of the most distinctive characters. The mouth is surrounded by three indistinct labial lobes, one of which supports a tooth. The vascular system is very peculiar, and presents a disposition met with in but few nematoid worms, the œsophagus having posteriorly a cœcal prolongation. Not in this point only, however, but also in the histological details to which the comparison was extended, did *Filaria piscium* agree with the supposed *Spiroptera hominis*."

"But the worm is said to have come directly from the urethra, that is to say, from the bladder. How did it get there? It is impossible that a nematoid, whose proper habitat is the body of a fish, should, even in an exceptional case, inhabit the urinary bladder of a warm-blooded animal. Such a supposition is contrary to all that we know of the developmental history of the Entozoa. It is far more probable to suspect that the person had herself introduced the worms into that situation. Instances of a similar kind with various articles are common enough. The *Filaria piscium* could be readily procured in London, and would be well known to any one in the custom of eating fish. How well known and abundant they are may be gathered from the circumstance, that in

Copenhagen the haddock is not eaten in summer owing to its containing too many of these parasites. There is no reason, therefore, for surprise at the circumstance that the patient in question in the course of two years passed one thousand of these worms, and that the deception was carried on for so long a time."

The contents of the second bottle are next referred to, with less particularity; and I shall immediately have occasion to revert to them in my description of the next spurious entozoon, namely, the *Diplosoma crenata* of Farre. Meantime, let it be also noticed that Schneider subsequently adds: "But if any doubt could be entertained as to a deception in this case, none whatever can attach to the contents of the third bottle. This (latter) contains round, tolerably-firm, vesicular bodies, which passed through the catheter when introduced into the bladder. Mr. Barnet regarded these bodies as the ova of the worm, and Rudolphi as '*concrementa lymphatica.*' But it is clear beyond all dispute that they are the ova of a fish of which they exhibit every distinctive character, the facetted outer membrane covering the cells of the *membrana granulosa*, beneath which is the shagreen-like coat, and, lastly, the vitellus with its large oil globules."

Such a complete *exposé* as the above has seldom been met with, and it is not a little singular that the deception should have remained so long undiscovered. Some little blame, indeed, naturally attaches itself to those of our countrymen who had previously examined these worms; blame or discredit, at least, in so far as they failed to recognize the true character of these structures. For my own part, I may say, that when some little time ago I examined (with the naked eye only) the worms still preserved in the Museum of the Royal College of Surgeons, I observed that there were no specimens in the bottle which could be referable to the *Filaria piscium*, and although the specimens were stated in the Museum Catalogue to be examples of *Spiroptera hominis*, they were, in truth, only the long "*concrementa lymphatica*" which Farre has minutely investigated, and, unfortunately, has described as constituting a distinct species of entozoon. The bottle, moreover, contains some small rounded granular bodies, which I have little doubt are piscine ova, like those discovered by Schneider in the contents of the third bottle which he examined.

3. DIPLOSOMA CRENATUM.

D. crenata, Farre; Beale.
Spiroptera hominis (in part), Rudolphi.

No one who takes the trouble to examine the two figures given in the plate accompanying Lawrence's original paper will fail to perceive that two very different bodies are there represented. Dr. Arthur Farre long ago noticed this remarkable difference, and, therefore, not unnaturally, arrived at the conclusion that the worm-like bodies, in question, were referable to two different species of Entozoa. With the view of throwing further light upon the subject he carefully, and with the aid of the microscope, examined the larger of the two worm-like bodies, and subsequently published the results of his inquiries. The smaller worm he allowed to retain the title of *Spiroptera hominis*, whilst to the larger, double, worm-like body, he applied the new generic and specific title of *Diplosoma crenata.* However unpleasant it may be to differ from an authority whom all so much respect, truth compels me to state that the so-called Diplosoma is no worm at all. In this opinion, moreover, I find myself supported by Leuckart, who, when he was over here, in 1862, cursorily examined the specimens at the College of Surgeons' Museum, and afterwards told me that he agreed with me in the opinion which I then entertained. I have, too, through the kindness of Dr. Farre, had an opportunity of studying his recent *brochure*, the elaborate contents of which, however, failed to convince me that his *Diplosoma crenata* was a genuine parasite. Dr. Beale, nevertheless, in his able little treatise on "Urine and Urinary Deposits" gives to Dr. Farre's opinions the most unqualified support. He writes (first edition, 1861, p. 322) as follows :—"The most remarkable case on record in which worms were passed from the urinary bladder is one which is reported by Dr. Arthur Farre, who has made some most careful dissections of the worm, and observations on the anatomy of the ova ('Archives of Medicine,' vol. i., p. 290). This is the case recorded by Mr. Lawrence in Vol. I. of the 'Med.-Chir. Trans.' translated in the year 1811. It is the only one on record. Dr. Farre describes the general characters of the worm in the article 'Worms,' 'Library of Medicine,' vol. v., p. 241. Rudolphi, on insufficient evidence, declared that these worms were merely lymphatic concretions; and, in consequence, this interesting and authentic case has not yet been properly noticed by writers on parasites. From the recent re-investigation of the whole subject, there can be no doubt that Rudolphi was wrong in his conclusions, and that these were real sterelminthous worms. In his paper, above referred to, Dr. Farre at once sets all doubt on the question at rest. He now describes the minute anatomy of the worm, and the characters of the ova."

Here, again, I am obliged to appear impolite, but truth compels me to state that I cannot share in the views advocated by Dr. Beale. I agree with him in admitting that the bodies in question were not *concrementa lymphatica*, but I cannot allow that they are Entozoa. They are evidently identical with the vermiform masses contained in one of the bottles sent to Rudolphi, of which we have the following account in the English version of Schneider's paper above quoted. They are there described as follows :—"A second bottle contains several slender shreds of matter, about an inch in length, which have also been noticed by Rudolphi, who describes them as '*concrementa lymphatica*.' Their structure and origin Dr. Schneider could not determine with any certainty, but considers it not improbable that they are portions of intestine cut fine." It thus appears that up to the time at which I am now writing, even those who differ from Farre and Beale do not feel themselves at liberty to speak quite positively as to what these *concrementa* really are. Throughout, indeed, it has been much more easy to state what they are not, than what they are. Helminthological science is much indebted to Schneider for his discovery of the true nature of the so-called *Spiroptera hominis*, and we are no less indebted to him for paving the way to a right understanding of the *concrementa lymphatica.* Dr. Farre's minute microscopic details, also, by their negative evidence, materially help one in arriving at a true estimate of their character, although, unfortunately, they have led him to a diametrically opposite conclusion. For my own part (thanks, in some measure, to the hints conveyed by Schneider's communication), I have arrived at a very definite opinion respecting these examples of the so-called *Diplosoma crenatum.* I may be in error, but I believe them to be carefully-cut slices of the ovisacs of the cod and haddock; the so-called "lateral membranous flaps" answering to the well-known ovarian laminæ which are developed in the peculiar ovisacs common to most osseous fishes. From these laminæ the piscine ova are ordinarily suspended in the early stages of their development, but they are subsequently cast off by a process of internal dehiscence, when they naturally, by their great numbers, fill up the general cavity of the ovisac, constituting the familiar hard roe. Ultimately they become the free, evacuated spawn. Thus the ingenious patient, in the present case (troubled with *Diplosoma crenatum*, *Spiroptera hominis*, *Concrementa lymphatica*, and what not!) had, I believe, succeeded in puzzling her medical attendant, and others, by resorting to the expedient of cutting up the ovarium of a haddock, and inserting portions thereof, along with the entozoa of the fish, into her urethra! Certainly, it requires a tolerably minute acquaintance with natural history and comparative anatomy, to enable one to fathom the mysterious habits of individuals who, for the purposes of deception, or otherwise, can thrust into their bladders such strange kinds of pseudelminths.

4. GORDIUS AQUATICUS.

G. aquaticus, Gmelin; Cuvier; Baird; etc.
G. seta, Müller; Diesing.
Seta palustris, Plancus.
Vitulus aquaticus, Seta, Aldrovandus.
Amphistoma aquatica, v. a., Seta, Conrad Gesner.
Lumbricus aquaticus, Klein.
Filaria Locustæ, Schrank; Rudolphi; Fitzinger; etc.
F. Ditisci marginalis, Von Siebold.
F. Grylli, Gmelin; Zeder.
? *Ophiostoma Pontierii,* Cloquet; Chiaje; Bremser.
? *Nematoideum hominis,* De Gland; Leveillé; Clesius.

From the evidence which has already been adduced respecting the introduction of peculiar worm-like bodies into the urine or bladder, with the view to deception, no one need be in the slightest degree surprised to learn that the common little hairworm of our ditches, ponds, lakes, and freshwater streams occasionally finds its way into the chamber-utensil. Interesting as it might prove, there is here no necessity to enter into the habits and life-history of this little nematode; but it may as well be mentioned, in passing, that although not a human helminth, the *Gordius aquaticus* is a true entozoon, inasmuch as it takes up a temporary residence in the bodies of various insects. The medical practitioner would do well to familiarise himself with its appearance, since it is not an uncommon trick with young people to procure the worm for purpose of puzzling the doctor. In the Museum adjoining the Middlesex Hospital we have a Gordius which was brought to an M.D. (since deceased), who, notwithstanding his eminence as a physician, was induced to believe that the worm in question was a genuine Dracunculus. It is said, moreover, that he paid four guineas for the specimen! Some twenty years ago, I remember to have seen a case in the private practice of Mr. Crosse of Norwich, where a young woman tried to deceive that distinguished surgeon by placing one or two Gordii in the chamber-pot; and, only very recently, another similar case has been brought under my notice by Dr. Bree of Colchester. I have no doubt many such cases have occurred in the experience of those of our medical brethren who are occupied with country practice. The worm has a deep chestnut-brown or blackish colour, is usually about a foot in length, and scarcely more than $\frac{1}{20}''$ in breadth. It has the peculiar habit of coiling itself into knots, whence its generic name. The sexes are distinct, the male being easily recognized by its bifid caudal extremity. The tail of the female is simple and rounded.

Before concluding, it remains for me to notice categorically, and with the brevity they deserve, the following so-called parasites :—

1. *Cercosoma,* Canali and Brera; Bremser; Rudolphi; Siebold; Diesing. This is the larva of *Eristalis tenax,* or *E. pendulum,* which had accidentally got into the urine.

2. *Ditrachyceras rudis,* Sultzer; Bremser; Eschricht; Diesing; Lerreboullet; = *Diceras rude,* Rudolphi; Lamarck; = *Cysticercus bicornis,* Zeder. This turns out to be a carpel of the mulberry (*Morus nigra*), which had been "macerated and deprived of its colour by digestion!"

3. *Sagittula hominis,* Lamarck; Chiaje; Blainville; Siebold; Diesing (gen. fict.); = *Animal bipede,* Bastiani. According to Von Siebold, this is a fragment of the hyoid bone of some bird which was passed with the fœces.

4. *Diacanthus polycephalus,* Stiebel; Bremser; Rudolphi; Diesing (gen. fict.). The illustrious Blumenbach determined this to be a raisin-stalk which had been evacuated *per anum.*

5. *Acephalocystis racemosa,* Cloquet. Under this heading we may place all those grape and current-like hydatigenous formations so frequently present in certain morbid affections of the chorion.

6. *Ascaris conosoma,* Jördens and Lenz; Brera; Bremser;

Rudolphi; Diesing. This, according to Brera, is the larva of *Musca domestica* found by Bretschneider in the human intestinal canal.

7. *Ascaris stephanostoma*, Jördens and Lenz; Brera; Bremser; Rudolphi; Diesing. Brera regarded this as the larva of *Musca carnaria*; also found by Bretschneider in the same situation.

8. *Thelazia*, Bosc and Rhodes. This parasite is a larval insect from beneath the eyelid of an ox.

9. *Filaria zebra*, Mongrand. Found in the left saphena vein of a slave (forçat). Robin and Davaine regard this as a fibrinous coagulum.

10. *Ovuligera carpi*, Dupuytren; = *Acephalocystis plana*, Laennec. These are merely concretions found between the tendons and muscles.

11. *Nettorhynchus Blainvillei*, Zenker. According to Raspail, this may have been a partially decomposed *Bothriocephalus claviceps* or *B. rugosus* of the salmon.

12. *Furia infernalis*, Linneus. Even Moodeer and other naturalists formerly believed in the existence of this altogether fabulous parasite.

The above list might be very much extended if one were at liberty to dignify every worm-like foreign body (that has been known to occur within the human body) with a generic and specific designation. Perhaps the most common Pseud-entozoa, presenting neither animal nor vegetable organization, are lymph-clots or concretions. Occasionally these formations present a most striking resemblance to nematodes and even other parasites. I have drawings from specimens formerly in the collection of Mr. Crosse of Norwich which might very well be taken for representations of the well-known ectoparasitic crustacean *Lernæa branchialis*, or some other of its numerous congeners. The fibrinous concretions, in question, were coughed up from the lungs. To Dr. Hughlings Jackson, to Dr. Lowe of Lynn, and to Dr. Thurnham (of the Wilts County Asylum), I am severally indebted for three worm-like productions of this kind from the intestines and urinary bladder. The specimen sent by the last-named gentleman was, however, from the alimentary tube of a parrot. Next to these in frequency we find a number of miscellaneous substances, the nature of which ought not, perhaps, to have been so readily overlooked. Thus the fibro-vascular cellular tissue of celery (or *Striatula* of authors), the carpellary segments of the orange (Edinburgh University Anatomical Museum), portions of the *ligamentum nuchæ* and other fragments of yellow tissue, the trachæa of a bird (*Physis intestinalis*, Scopoli), entire undigested blood-vessels, jointed barley-stalks, the beard or awn of grasses, earwigs, millipedes (*Geophilidæ*), woodlice (*Oniscidæ*), wood-shavings, and many other substances have been, at one time or other, classed as parasites. Perhaps, the most remarkable pseudelminth which has been placed in my possession is a tænia-like body which I owe to the kindness of Professor Aitken. It was removed, *post mortem*, from the intestinal canal of a private soldier, in the month of June, 1862. Neither Dr. Aitken nor Leuckart (to whom I showed the specimen, and who took away a small portion for microscopic examination) could decide what the substance was, and up to the present time I have been unable to solve the difficulty. Meanwhile I may observe that it exhibits a general tænioid form, is marked by numerous obliquely transverse and very fine ridges, and on section displays two patent orifices in the situation (curiously enough) ordinarily occupied by the great lateral water-vascular canals of any ordinary tapeworm. Its structure is firm; but it is clearly neither an entozoon nor an animal of any kind whatsoever.*

Lastly, it may be well to furnish a more or less complete list of the insects, bots, bot-like larvæ, and caterpillars which have either been passed from the human subject, or have been accidentally or designedly introduced into the excrementa. Specimens of intestinal insect larvæ (and a Geophilus) are still, I believe, preserved in Mr. Crosse's collection at the Norwich Hospital. Dr. Leared has also recently brought an instance under my notice; and in November, 1862, I received, through Dr. Lankester, a caterpillar which " came away with the lochial discharge about three weeks after parturition." This, at least, appears to be the impression of Mr. Norton of Wateringbury, Kent, who reported the case to Dr. Lankester in a note, in which he compares the larva to Küchenmeister's figure (copied from Bilharz) of *Linguatula constricta.* It is, apparently, the larva of the common gooseberry moth (*Abraxas grossulariata*). The following is an excerpt from the Rev. J. F. Hope's instructive and elaborate tables of the so-called intestinal worms (insects, or their larvæ) producing *canthariacis, scolechiasis,* and *myacis* :—

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* Dr. Arthur Cribb has also recently sent me an account of a very singular worm-like body, stated to have been voided by the mouth. Two instances occurred in the same patient, who resides at St. Domingo. A diagram accompanying the description represents the so-called worm to be nearly six inches in length, being abruptly truncated anteriorly at the head, and sharply acuminated below. Its reported "pulpy nature," and subsequent disintegration (within the phial), during a "long journey," are points which sufficiently indicate its pseudelminthic character.—T. S. C., July 5th, 1864.

COLEOPTERA.

1. *Sphodrus leucopthalmus.* One case. By Paykull. Sweden.
2. *Dyticus marginalis.* One case. Rev. F. W. Hope. England.
3. *Dermestes* ——— ? (three larvæ) One case. Lister. England.
4. *Dermestes murinus.* One case. Otto. England.
5. *Dermestes lardarius.* Two cases. Otto; Chichester. England.
6. *Pæderus elongatus.* One case. Paykull. Sweden.
7. *Oxyporus subterraneus.* One case. Paykull. Sweden.
8. *Staphylinus splendens.* One case. Paykull. Sweden.
9. *Staphylinus politus.* One case. Paykull. Sweden.
10. *Staphylinus fuscipes.* One case. Paykull. Sweden.
11. *Staphylinus punctulatus.* One case. Paykull. Sweden.
12. *Geotrupes vernalis.* One case. Van Bromell. Sweden.
13. (Doubtful species.) One case. Rosen. Sweden.

14. *Melolontha* ——— ? Some larvæ. Two cases. Lemaout; Depalse; Robin; Desvoydy. Sweden; France.
15. *Tenebrio molitor.* Many larvæ. Nine cases. Bateman; Allen; Shaw; Forestus; Tulpius; Kellie; Pickells and Thomson; Traill and Gleadow; Acrel. England; Ireland; Scotland; Netherlands; Sweden.
16. *Blaps mortisaga.* Three cases (1206 larvæ in one instance). Pickells, Thomson, and Bellingham; Patterson; Bateman. Ireland; ? England.
17. *Mordella* ——— ? One case. Rosen. Sweden.
18. *Meloe proscarabœus.* One case. Germar. Silesia.
19. *Meloe* ——— ? One case. Anonymous.
20. *Meloe maialis.* One case. Otto. England.
21. *Balaninus nucum.* Two cases. Henry; Astley Cooper. England.
22. *Balaninus* (Larvæ unknown). Henry and Phillips. England.

DERMAPTERA.

23. *Forficula auricularia.* Two cases. Griffin. Ireland.

LEPIDOPTERA.

24. ? *Papilio brassica.* One case. Calderwood. Scotland.
25. *Noctua* (larvæ). One case. Dumeril. France.
26. ? *Noctua* (several larvæ). One case. Lister. England.
27. *Crambus pinguinalis.* Three cases (larvæ in two). Linneus, Church, and Angelinus. Sweden; England; Italy.
28. *Phryganea grandis.* One case. Church. England.

DIPTERA.

29. *Musca domestica.* Six cases (many larvæ). Fourcould and Geoffrey; Ruyschius; Reeve; Brera; Babington; Clarke. France; England.

30. *Musca carnaria.* Six cases. Roulin; Cloquet; Brera; Wahlbom; Cheyne; Bateman. England; ? Ireland; Sweden.
31. *Musca cibaria* (?). Two cases. Good and White. England.
32. *Musca vomitoria.* One case. Thomson. Ireland.
33. *Musca larvarum.* One case. Pickells. Ireland.
34. *Musca Cæsar* (?). One case. Thomson. Ireland.
35. *Musca* (larvæ of various species). Nineteen other cases. Thomson; Wohlfart; Latham; Mangles; Brooks; Ruyschius and Valisneri; Jennings; Sells; Leuwenhoek; Azara; Lemprière; Wahlbom; Tulpius; Pickells; Chichester. Ireland; England; Scotland; France; Sweden; Jamaica; Paraguay.
36. *Musca nigra.* One case. Wahlbom. Sweden.
37. *Elophilus pendulus.* Five cases. Bonnet; Kirby; Acrel; Ohhelius; Ziegler. England; Sweden; Italy; Switzerland.
38. *Stratyomis* ——— ? One case (larvæ). F. W. Hope. England.
39. ? *Tipula* (larvæ). One case. Kirby. England.
40. *Œstrus hominus.* Five cases. Howship and Gill; Treherne and Howship; Linneus (jun.) and Gmelin; Olivier; Rudolphi. South America; Surinam; Maraquita and Columbia; ? Prussia.
41. *Œstrus bovis.* One case. Clark. ? England.
42. *Œstrus Guildingii.* One case. Guilding. Trinidad.
43. *Œstrus* (larvæ of various species). Thirteen cases. Heysham; Chichester; Say and Brick; Roulin; Vallot; Arture; Guerin and Guinon; Goudout; Metax; Clift. England; America; South America; Philadelphia; Demerara; Maraquita and Columbia; Peru; Cayenne; Martinique.

The above list certainly comprises a formidable array of insects and their larvæ, said to have taken up their residence in the human body. Most of these parasites are recorded as having been procured from the stomach or intestinal canal, whilst not a few are stated to have been voided *per urethram.* Others are from various parts of the body. On the whole there can be little doubt that some few of these insects, or, at least, their larvæ, have really come from the above-named localities; but it may be not unreasonably doubted that the majority have been employed for purposes of deception. Which cases are genuine and which are false it is often impossible to determine. A short while ago Mr. Flower, F.R.S., placed in my hands an example of an insect which was stated to have been the cause of dysuria in a woman seventy years of age. The so-called parasite (with an account of the case) had been originally sent by a medical gentleman to Mr. Solly, F.R.S., who, like Mr. Flower, very naturally entertained a doubt as to its helminthic character. The patient gravely informs her medical attendant that "she feels relief as soon as she passes the fly;" having, altogether, got rid of ten or a dozen. On carefully examining the insect, I have no doubt whatever, that it is one of our common garden frog-hoppers (apparently *Aphrophora bifasciata*) in the imago condition. How it hopped into the locality above-mentioned, may, in this instance, be readily conjectured; but the remarkable case of Mary Riordan (where 1206 larvæ and some perfect insects were passed *per anum*) is unquestionably genuine; and the truthfulness of the latter record gathers additional strength from the evidence that she also voided, *per anum*, specimens of *Ascaris mystax* and *A. lumbricoides.* To this list may likewise be added the hexapodous larva of *Clerus formicarius*, which, according to Küchenmeister, "was given to Von Siebold as a urinary parasite." It is closely allied to *Dermestes.* Dr. J. M. Duncan has recorded a case of *Œstrus bovis* occurring in the human subject, and has also written a very interesting paper on "bots," in general, in the "Edinburgh Veterinary Review." The well-known essay on "bots," by Bracey Clark, is quoted by Duncan, and also by G. W. Spence, who has likewise contributed a paper to that ably-conducted periodical.

Mr. Joseph Gamgee has likewise written on the same subject. More precise references to these and other similar memoirs will be found in the Bibliography appended to this work.

Lastly, in connection with the subject of "bots," I have to express my indebtedness to Dr. Kirk, F.L.S., for several interesting specimens, accompanied with appropriate notices. Seven large Œstrus-larvæ are from the frontal sinus of a species of Hartebeest (probably *Acronotus lunatus*), killed twenty miles south of Lake Nyassa; five smaller "bots" having been procured from the stomach of a cow elephant shot among the hills lying north of the Victoria Falls, in Central Africa. More interest, however, attaches itself to a solitary larva of a species of Musca which had taken up its residence in Dr. Livingstone's leg. Dr. Kirk removed this parasite by incision; and, on a second occasion, he obtained a similar specimen from the shoulder of a negro. The natives affirm that the adult insect is not unlike, but rather smaller than our ordinary blue-bottle (*Musca vomitoria*). Dr. Kirk states that the species is not common. Burton mentions, it is added, that he had heard of it as occurring in an inland district in the neighbourhood of Zanzibar.

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THE END.

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ENTOZOA.

ENTOZOA

BEING A

SUPPLEMENT

TO THE

INTRODUCTION TO THE STUDY OF

HELMINTHOLOGY

BY

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PREFATORY NOTE.

Nearly five years having elapsed since the first appearance of my Treatise, the Publishers have thought that the issue of a Supplement—embracing a special and general Index, together with additions to the Bibliography and a record of researches conducted since the year 1864—would not only prove acceptable to those who have already possessed themselves of the work in its original form, but would also be likely to enhance its value, independently; and for myself, there is the advantage which it thus affords me of offering my sincere acknowledgments to the score or more of "reviewers" who have been pleased to honour my previous efforts with their favourable comments. The reviews in question have necessarily proceeded from unknown pens; but, as many of them contain useful information, I have supplied references to the more important under the title "Anonymous" in the Supplemental Bibliography.

The progress of Helminthological science abroad has not been so striking of late years as formerly, owing partly to the circumstance that several well-known investigators have turned their attention to other branches of zoology. My thanks, however, are due to several distinguished men who have furnished me with valuable communications. In this regard I am under much obligation to Dr. Rudolf Leuckart (formerly Professor of Zoology and Comparative Anatomy in the University of Giessen), and to Professors Claparède (Geneva) and Cornalia (Milan); also, in a scarcely less degree, to the late Dr. Diesing (Vienna), to Dr. Krabbe (Copenhagen), to Dr. Davaine (Paris), and to Dr. Peter Olsson (Lund).

To authors of papers written in the English language my indebtedness is too large to be acknowledged in detail; nevertheless I may, in this respect, particularise the names of Professors Aitken, Bastian, and E. Nettleship; with those of Drs. Murchison, Baird, Waring, P. H. Macgillivray, Macalister, Messrs. Alexander Agassiz (U. S.) and T. S. Ralph (Australia). For valuable MS. notes and suggestions I am likewise indebted to Prof. S. Percy, M.D., New York; to Prof. Gairdner, of Glasgow; and to Assist.-Surgeon Henry C. Brodrich, 1st Corps Central India Horse, stationed at Augur, in Malwa.

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T. S. C.

84, Wimpole Street, London,
May, 1869.

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ENTOZOA.

I.

ON THE HISTORY OF THE DISCOVERY OF TRICHINA SPIRALIS.

In the twelfth chapter of the second division of this work, I have glanced at the history of the so-called flesh-worm. Since the time of publication, however, circumstances have necessitated, on my part, a thorough and exhaustive examination of the very copious literature of this subject, both home and foreign. I have, certainly, no reason to regret the trouble taken, as it has enabled me to express, in reference to questions of priority, convictions which I have all along entertained, but which, from the peculiar surroundings of the case, I had hitherto been debarred from stating in their fulness. In a word, it may be said that the discovery of the Trichina, as a human parasite, rests essentially with Mr. Paget, F.R.S. This truth is proven by the discoverer's own letter, as well as by the joint communication of "Two former Presidents of the Abernethian Society, connected with St. Bartholomew's Hospital." The documents, together supplying all the missing links in the chain of evidence, were published by their respective authors in the "Lancet" for March 3rd, 1866. In effect, they authoritatively confirm the views I had expressed in a "foot-note" to a paper previously published in the same Journal. The true and essential facts of the case are none other than those here repeated; the present record being, in part, the same as the one above referred to. It is only right to add, in passing, that the question of priority, now fully and fairly established in Mr. Paget's favour, in no way detracts from the high merits of those other distinguished physiologists who have since made scarcely less important discoveries in connection with this truly remarkable parasite.

To the partially informed it may appear a work of supererogation to offer renewed details on this subject; but the wide-spread interest created by formidable outbreaks of the flesh-worm disease, together with the evident confusion still existing in the above expressed relation, render it most desirable that all students of helminthology should possess clear and definite ideas regarding the true sources whence our knowledge of the parasite has been derived. When, not long ago, a writer in an ably-conducted newspaper put forth a statement to the effect that the history of Trichina and Trichiniasis was "not yet clearly made out," and further, that "extensive series of experiments had led to no definite result," I felt called upon to correct this misapprehension, by addressing a letter in reply. As I referred the general reader to the best authors, I hoped, at the time, the matter would drop; but another writer supplemented my statement by pointing to Professor Owen as the discoverer of Trichina. This brought on further discussion, the particulars of which it is quite unnecessary to recapitulate. In the course of correspondence I expressed the opinion that the "little bodies" first noticed by Tiedemann in the year 1822,—thus anticipating Mr. Peacock (whose name had been incidentally mentioned) by six years,—were neither more nor less than those calcified and degenerated little cysts which we now know to be the so-called Trichina capsules.* "Happily," I remarked, "the discovery of the actual 'flesh-worm,' itself, will continue to be imperishably associated with the names of Owen, Paget, and Wormald, whilst the scarcely less important discovery of the lemon-shaped or calcified capsules must permit a similar bracketing of the names of Hilton, Peacock, and Hodgkin." The *merit of priority of discovery is gradational both in degree and in kind*, but in order to establish the relative degrees of priority involved, it is necessary to display entire accuracy of criticism. Respecting the main facts, I believe the following to be decisive:—

---

* See Frorieps' "Notizen," the title-page of which bears the date of 1822; but, in point of fact, the date of publication of the notice in question was August, 1821.

So far as regards the parasite itself, it must be apparent to all who have perused the standard treatises and monographs of Küchenmeister, Leuckart, Davaine, and Pagenstecher, that there has been no indisposition on the part of continental writers to render to our countrymen their legitimate meed of praise; whilst, at home, naturalised foreigners, such as Dr. Thudichum and Althaus, have honourably followed the same track. All these authors' works I have before me; their several historical records being substantially the same. In this treatise on "Entozoa" I purposely avoided giving a lengthened account of the history of Trichina, because I supposed "the circumstances attending the discovery of this parasite" were "so familiar to the English reader" as to render such a step unnecessary (p. 335).

At the time to which I have previously alluded, it was even hinted that I had been attempting to take from our countrymen the merit of the discovery of the trichinous disease. It will be seen that such an intention was far from my thoughts; for, at p. 335 of the present work, I have said:—"To my mind this discovery is one of the happiest to which Englishmen can point."

The passage in Frorieps' "Notizen" which seems both to Henle and myself to describe, somewhat rudely perhaps, a genuine case of Trichina, stands as follows:—

"Tiedemann fand bei der Leichenoffnung eines Mannes, der ein starker Branntwein-trinker gewesen, und nach mehreren heftigen Gichtenfällen an Brustwassersucht gestorben war, in den meisten Muskeln, vorzugleich an der Extremitaten weisse steinige

Konkremente. Sie lagen zwischen den Faserbündeln in Zellgewebe; haufig auch an der Wänden der Arterien waren zwei bis vier Linien lang und rundlich. Die chemische Untersuchung welche Gmelin veranstaltete zeigte darin 73 Theile phosphosauren Kalk, 7 Theile kohlenstoffsauren Kalk, und 20 Theile einer thierischen, dem Eiweiss oder Fibrin ähnlichen Materie."

This paragraph I translated thus:—"At the post-mortem examination of a man who had been a great brandy-drinker, and who died from thoracic dropsy after several severe attacks of gout, Tiedemann found white stony concretions in most of the muscles, especially at the extremities. They lay in the cellular tissue between the fibre-bundles; frequently also attached to (or near) the walls of the arteries, being from two to four lines long, and roundish. The chemical examination conducted by Gmelin yielded seventy-three parts phosphate of lime, seven parts carbonate of lime, and twenty parts animal matter, resembling albumen or fibrin."

Now, in regard to this passage, it has been correctly stated that Leuckart denies that we have here to deal with Trichina. In this particular opinion Leuckart stands almost alone—I mean amongst recognised helminthologists who have honestly investigated the matter and have conducted experiments with Trichina. I am sure neither Pagenstecher nor myself would willingly detract one iota from Leuckart's authority; but I hold that we are both entitled (as original and, for many years past, laborious workers in the field of helminthology) to express a contrary opinion, in accordance with our convictions. Pagenstecher, referring to the views entertained by this distinguished investigator, remarks:—"Leuckart hat irrthümlich dieses Citat fur falsch erklärt."* Henle appears to have been the first to have pointed to the passage of Tiedemann as describing an example of Trichina; and in this reference he has been followed by Diesing, Küchenmeister, Davaine, Thudichum, and Aitken. But I am under the strongest impression that only Henle, Leuckart, and Pagenstecher examined the original passage for themselves before they placed their references on record.

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* See foot-note to p. 4 in his recent work "Die Trichinen." Leipsig, 1865. This beautiful memoir contains a report of experiments performed at the Zoological Institute of Heidelberg, by Professors C. J. Fuchs and H. A. Pagenstecher, by order of the Baden Grand-ducal Board of Trade.

It would hardly be fair to say that Pagenstecher dissents from Leuckart's view of the question of priority. To put the matter clearly, however, it is necessary to state precisely what he really does say. Speaking of Tiedemann's notice, he writes ("Die Trichinen," s. 4):—

"This communication was also refered by Henle to such a development when he subsequently found Trichina; and in this sense it was afterwards received by Diesing, Küchenmeister, and Davaine. But it has been rejected by Leuckart on account of its size (from two to four lines) and seat of the concretions. True, it has never yet been observed that the capsuled Trichina (not measuring a tenth part of that diameter) subsequently constituted centres of gouty deposit exceeding their own bulk; nor is it likely that they should. Seeing, however, as we often do, that errors repecting size have crept into works on Trichina, we shall not need to lay much stress upon these statements; still less so since the notice is very superficial, and its character is essentially of a physiologico-chemical nature. But this, at least, seems to us decisive, that when Bischoff, at Heidelberg, wrote on a case which occurred in Heidelberg, not one single word was mentioned respecting a former case, if such should have happened, although Tiedemann and himself were on terms of close intimacy. Our hope to be able to produce a further decision by the examination of the preparation preserved in our anatomical collection has been disappointed; nothing of the kind could be found."

From this extract it seems that my view does not gain Pagenstecher's entire support; although, in a foot-note, he remarks that Leuckart has erroneously declared Henle's quotation to be false. Leuckart, perhaps, only referred to the source of the notice.

Pagenstecher further goes on to discuss Klencke's claims to the discovery of Trichinæ. He says :—

"Klencke has asserted that he had already drawn Trichinæ in the year 1829, and that he had seen them again in 1831. This subsequent statement has no kind of confirmation, The unreliableness, mistakes, and self-deceptions in the helminthological writings of Klencke have been repeatedly exposed some twenty years ago."

As I have said, I cannot but believe that Tiedemann's notice describes Trichina capsules. The real difficulty is the size there given. With me, this goes for next to nothing; for, as Pagenstecher himself has pointed out, similar errors have been made by able writers. Thus Virchow erroneously described intestinal Trichinæ to be four lines in length; whilst, on the other hand, Vogel spoke of free Trichinæ as one-hundredth of an inch long—"the former statement being just as much too exaggerated as the latter is too small." Whatever be the true state of the case, if the facts permitted, I should be well content to say with Pagenstecher, "Es darf also wohl unbedingt Hilton als der Entdecker der Trichinen gelten." I will admit that a legitimate doubt hangs over the claims of Tiedemann, whilst no doubt can be entertained that Hilton was the first to ascribe to these bodies an animal nature.

When it is asked, Who discovered Trichina? we must frame our reply according as to whether the inquirer refers to the worm itself, the disease which it superinduces, or the pathological appearances which its presence occasions. Summarily, my answer may be categorically expressed as follows :—

1. Mr. Paget first actually determined the existence of the entozoon which was subsequently more completely described by Professor Owen. Mr. Paget was assisted in the discovery by the celebrated botanist, Robert Brown, who lent his microscope for the purposes of examination.

2. Professor Owen first scientifically described and named the

flesh-worm *(Trichina spiralis)* in the published transactions of a learned Society. He first fully interpreted the true nematoid nature of the parasite.

3. Mr. Wormald had "more than once" previously noticed the characteristic specks "in subjects dissected at St. Bartholomew's" Hospital. He transmitted the individual specimens which enabled Owen to draw up his valuable paper.

4. Mr. Hilton was the first to suggest the parasitic and animal nature of the specks observed in human muscle. He anticipated Wormald in his observation of the "gritty" particles in dissecting-room subjects, and described the bodies as "probably depending upon the formation of very small cysticerci."

5. According to Dr. Hodgkin, "the first observation of these little bodies was made in 1828" by Mr. H. Peacock. The latter made a dried preparation of the *sterno-hyoideus* muscle to display the specks. That preparation is the oldest in existence, and may be seen in Guy's Museum.

6. Henle, Diesing, Küchenmeister, Davaine, Thudichum, and Aitken have pointed to a notice by Tiedemann as probably, or possibly, indicating a prior observation of the specks. Leuckart rejects the evidence. Pagenstecher appears to be in doubt as to the nature of the bodies in question. I have long entertained, and still entertain the persuasion that the passage in question gave a rough and imperfect description of the now familiarly known calcified Trichina capsules.

7. Herbst was the first to rear muscle-flesh-worms, or encapsuled Trichinæ in animals by experiment (1850); and Virchow was probably the first to rear and recognize sexually mature intestinal Trichinæ by experimenting upon a dog. (Deutsche Klinik, 1859, s. 430.)

8. Leuckart was the first to offer a full, complete, and correct solution of the principal questions relating to the source and mode of genesis of the flesh-worm (1860). He disproved the erroneous views of Küchenmeister.

9. Zenker opened up a new epoch in the history of trichinal discoveries. He first observed the young in the act of migration, and was the first to demonstrate that these parasites were capable of giving rise to a violent disease in the human body.

If any one of the above conclusions can be shown to be incorrect I shall be happy to abandon it. To myself, it is clear that Mr. Paget first discovered the worm. Owen first scientifically described it. Wormald transmitted the specimens to Owen, having himself previously seen similar calcified bodies. Hilton met with cases before Wormald, and first suggested the animal nature of the specks. Peacock anticipated Hilton in noticing the specks. Tiedemann probably anticipated Peacock.

By way of supplementing the first of the above conclusions, it only further remains for me to add that Mr. Paget speaks of Mr. Robert Brown as having himself "dexterously pulled a worm from a cyst." Mr. Brown was, therefore, the second person made acquainted with the parasite through Mr. Paget's instrumentality, as Mr. Children appears to have been the third. Portions of the trichinised muscle were afterwards "distributed far and wide," and it was not unnatural that specimens should immediately pass into the hands of Professor Owen, who, of all men then living, would be more likely than any one else to throw light on the structure and zoological affinities of the entozoon.

Those who desire yet fuller information than is here given, should read the original letters above referred to. To these documents (to which references will be found in the Supplemental Bibliography) I would especially direct the attention of foreign helminthologists—the more so, since there are persons, on this side the channel, who systematically ignore the labours of their own countrymen.

II.

RECORD OF SUCCESSFUL EXPERIMENTS WITH TRICHINA SPIRALIS.

In conducting these investigations I received the co-operation of Professor Simonds and Assistant-Professor Pritchard, of the Royal Veterinary College. The results were originally communicated by me to the Linnean Society:—

Exps. 1 and 2. On the 15th of March, 1865, an ounce of flesh containing Trichinæ was administered by myself to a black bitch. The dog being destroyed five days subsequently, neither intestinal nor muscle-trichinæ were discovered. It was thought that the dog had thrown up the bolus, which was strongly saturated with chloride-of-zinc solution. The bolus consisted of a portion of the *pectoralis major* of a subject brought to the dissecting-room at the Middlesex Hospital. The cysts were highly calcified; but the majority contained living embryos, which were quite unaffected by the zinc-solution injected into the body to prevent decomposition. At the same date a small white puppy was experimented on and examined with precisely the same results. In either case it was, of course, too early to expect muscle-flesh-worms to have become developed.

Exp. 3. Half an ounce of the same trichinous human flesh was given (at the same date) to a black-and-tan puppy reared at the Royal Veterinary College; a second "feeding" being administered on the 21st of March, or six days after the first. In this case Mr. Pritchard, who fed the animal, took the precaution to chop the muscle into small pieces and to mix it with other food, in order that the flesh might be the more readily retained in the stomach. The puppy was not destroyed until the 15th of the following June, when, on examination, numerous encysted but non-calcified muscle-Trichinæ were found in all the voluntary muscles subjected to microscopic scrutiny.

Exp. 4. An ounce of the same flesh was given to a dark-coloured pig on the 15th of March, and again on the 20th, several other "feedings" being also administered during the month of April (1865). It was destroyed on the 16th of May; but no Trichinæ were detected.

Exp. 5. An ounce of the same human muscle-flesh administered to a small sheep (which was subsequently killed on the 29th of June) produced the same negative results.

Exp. 6 and 7. "Feedings" were at the same time administered to a rat and mouse. The mouse died on the 2nd April, when I examined its muscles without success. On the following day the rat unfortunately made its escape, but whether trichinized or no I cannot say.

Exp. 8. An ounce of trichinous human flesh was given to a donkey, in the form of "balls," on the 20th of March; and during the month of June four other separate "feedings" with trichinous dog's flesh were also administered. The animal was removed from the College without the result being ascertained.

Exp. 9. From the 15th to the 20th March, 1865, inclusive, three small Trichina "feedings" were likewise administered to a guinea-pig. This little animal was not destroyed until the 15th of the following June, when a positive result was obtained. The *pectoralis transversus* and other muscles were found to harbour a considerable number of encysted Trichinæ.

Exp. 10. On the 20th March, and again on the 21st (1865), "feedings" from the same human subject were administered to a hedgehog. On the 26th of April the animal seemed to be attacked with symptoms of Trichinosis. It refused food, kept its head extended and the eyelids closed. On the 27th it appeared much worse, and on the morning of the 28th it was found dead. On the 29th I examined the flesh, and found abundance of living Trichinæ in the muscles. The capsules were very thin and transparent. A few days later Mr. Simonds also examined the flesh, and confirmed this result.

Exps. 11 and 12. Two chickens were fed, on the 21st of March, with the same material. One of the birds died on the 24th, when I examined the intestines and detected one or two very minute nematodes, which, at the time, I believed to be imperfectly developed Trichinæ, but subsequently saw reason to alter my opinion. The other bird died on the 3rd of April, and certainly contained no muscle-Trichinæ.

Exp. 13. On the 22nd and 23rd of March, "feedings" amounting to an ounce of flesh in all were given to a mole. This animal was returned to the care of Mr. Charles Land, who had previously sent it to the Veterinary College. He subsequently reported that, after observing the mole to be "working" for two or three days, he lost all trace of it, and concluded that it had either escaped or was dead.

Exp. 14. On the 1st and 2nd of May, portions of the left fore extremity of the hedgehog (in which we had successfully reared *Trichina* from the Middlesex-Hospital subject) were offered by Mr. Simonds to a cat. It ate the flesh very readily, consuming the entire limb. On the 15th of the following June the cat was killed, when living Trichinæ were found within all the muscles which we examined.

Exp. 15. At the same dates a young terrier dog was similarly treated, but did not take the "feeding" so readily. In this case the left hind extremity of the hedgehog was employed, and what was not eaten voluntarily was forcibly introduced. On the 1st of June the dog was attacked with "distemper," and died on the 8th of the same month. On examination we found several living Trichinæ in the *sterno-maxillaris* and other muscles. Some of the parasites were encysted.

Exp. 16. From the 9th to the 12th of June, inclusive, four separate worm feedings with the flesh ef the trichinized terrier-dog were administered to a crow. The bird was killed some months afterwards and sent to me for examination. Its muscles were entirely free from Trichinæ.

Exp. 17. From the 9th to the 17th of June, inclusive, seven separate worm-feedings were administered to a pig. One of the "feedings" was with the trichinized guinea-pig's flesh, the others from the dog. This animal was not destroyed until the 4th of April, 1866, when all the muscles which I examined were found extensively infested with Trichinæ. There were probably not less than 16,000,000 present, all being alive and enclosed within perfectly-formed capsules, none of which latter exhibited any traces of calcareous deposition.

Exp. 18. Four separate "feedings" with trichinous dog's-flesh were likewise, at the same dates as the foregoing, administered to a rat. This experimental animal, however, like the one previously mentioned, contrived to make its escape. I fear it was well trichinized.

Exp. 19. About the same date trichinous "feedings" were given to a black puppy (bred at the Veterinary College). The dog was killed on the 18th of August, 1866, having also been made the subject of an echinococcus-feeding, when I found abundance of encysted Trichinæ within the voluntary muscles.

Exp. 20. Four separate worm-feedings with the flesh of the trichinized guinea-pig were given to a sheep on the 15th, 16th, 17th, and 19th days of June, 1865. The experimental animal was destroyed on the 29th of the same month; but the result was negative.

Exps. 21 and 22. "Feedings" with the guinea-pig's flesh—four in the one case and three in the other—were also administered by Mr. Simonds (from the 15th to the 19th of June, inclusive) to a chicken and a goose respectively. These birds were destroyed some months afterwards and sent to me for examination; but the most careful scrutiny failed to detect any Trichinæ within their muscles. The goose was cooked and eaten without the slightest hesitation. The chicken I found too tough for consumption.

Exp. 23. On the 28th of March of the present year, I obtained a small quantity of muscle from a highly trichinized German subject, who died, from the effects of an accident, at the London Hospital the day previous. The case was fully reported by Dr. Thudichum in a new journal, called "Scientific Opinion," (No. 4, April 25, 1866, p. 55). During the same day (at 2.30 P.M.) I fed a dog with part of this human flesh. On the morning of the 31st I killed the dog, and examined the intestinal canal (at 11.30 A.M.), which revealed the presence of sexually mature living Trichinæ. The males (of one of which I retain an accurate figure) displayed the characteristic bilobed caudal appendage, leaving no doubt as to their source and nature. I have mentioned the precise time of the experiment, in order to show that a period of sixty-nine hours proved amply sufficient for the development of the young muscle-flesh-worms of the human subject into the sexually mature adult Trichinæ of the dog.

Exp. 24. With another portion of this human flesh (taken from the muscles of the tongue) in which the Trichinæ were extraordinarily abundant, I fed a cat. In about ten days the animal showed the most marked symptoms of Trichinosis. It refused to eat; the eye lost its lustre; the body became very thin, and I thought the animal would die. By very great care, keeping it warm before the fire, and subsequently inducing it to take a little milk, the creature improved, gained flesh, and eventually recovered. About three months afterwards I destroyed this cat, when, on examining the *panniculus carnosus*, *latissimus dorsi*, and other superficial muscles, I found great quantities of well-developed, capsuled Trichinæ. Although the animal had swallowed scarcely a quarter of a ounce weight of infested flesh, yet thousands of parasites had been propagated in its flesh, and a nearly fatal helminthiasis set up. Dr. Thudichum, who saw the trichinized German subject, estimated the number of parasites in his body at 40,000,000. I do not think this estimate likely to be exaggerated; for if all the flesh had been infested to the extent I found to obtain in respect of the muscles of the tongue, I believe 100,000,000 would have been tolerably near the mark. In places the point of a needle could not be thrust between the capsules, so closely were they agglomerated.

Exp. 25. From the 19th to the 25th of April, 1866, inclusive, daily administrations of trichinous pork, in the form of bolus, were given to a sheep by Mr. Pritchard. The Trichinæ were from one of our experimental animals at the Veterinary College, about two ounces of the flesh being taken at each feeding. The flesh of the sheep (destroyed in the following November) failed to give any indication of the presence of the offspring of these parasites.

Exps. 26 and 27. About the same time, and occasionally at intervals extending over a period of five weeks, Mr. Pritchard also fed two young fowls with the same trichinous pork. Towards the close of October, 1866, both birds died, when Mr. Pritchard carefully examined the flesh of them, but failed to find any trace of Trichinæ.

Exps. 28 and 29. From April 2nd to the 9th of the same month, 1866, inclusive, feedings with trichinous pork were likewise given to two more dogs. These animals were destroyed and examined by Mr. Pritchard in November, 1866; but the result appeared to be negative.

Remarks.—The results as here given correspond very closely with those obtained by investigators on the continent. Thus the seven experiments on birds (including five fowls, one goose, and one crow) were all negative. This conclusion, so far as muscle-Trichinæ are concerned, accords precisely with the experiences of Professors H. A. Pagenstecher and C. J. Fuchs, at the Zoological Institute in Heidelberg. These experimenters, it is true, found that the ingested muscle-Trichinæ acquired sexual maturity within the intestinal canal of their avian "hosts;" but they never found young

Trichinæ in the muscles of the birds, nor did they perceive any evidences of an attempt on the part of the escaped embryos to effect a wandering or active migration on their own account. Clearly, if the bird's intestinal canal were a proper territory for the residence of sexually mature Trichinæ, Drs. Pagenstecher and Fuchs would have found abundance of wandering and non-encapsuled flesh-worms, and we should have obtained (owing to the greater length of time which we generally allowed to elapse before destroying the experimental animals) sexually immature muscle-Trichinæ enclosed in well-formed capsules with, in some instances, more or less calcareous degeneration. I have put the matter thus pointedly, because not a few persons still entertain the notion that Trichinæ are liable to infest all kinds of warm-blooded, and even, also, many kinds of cold-blooded animals, such as reptiles and fishes. Certain nematodes found in earth-worms have been described as Trichinæ; and, consequently, pigs and hedgehogs were said to become trichinous through eating these annelids. The minute flesh-worms described by Bowman from the muscle of the eel are not true Trichinæ, any more than the somewhat similar parasites (*Myoryktes Weismanni*) which Eberth found to infest the muscles of the frog. The same may also be said of Dr. Salisbury's *Trichina cystica*, described in Dr. Hays' American Journal. (For ref. see Bibliography.) The negative results above obtained may therefore fairly be taken as positive, in one sense, inasmuch as they help us, with the aid of other experiences, to define the area of distribution legitimately assignable to *Trichina spiralis* as a good nematode species. Taking in connexion with what we know touching the limitations of distribution or occupation affecting other species of parasites, the facts have a special and very peculiar significance; one, however, upon which I cannot here enlarge. Deducting, therefore, from the twenty-nine experiments the seven instances among birds, where the flesh-worms would not develop themselves, and also the three separate cases where the experimental animals escaped, together with one other case where no opportunity of examination was afforded, we have left us exactly eighteen mammals in which the results were, in all but two, very carefully ascertained. The exceptions were those of the first two dogs experimented on some two years back. The intestinal canal, or rather its mucous contents, were not sufficiently examined to enable me to affirm positively as to the absence of sexually mature Trichinæ. In a more recent instance (Exp. No. 23) I had evidence of the difficulty of finding the mature Trichinæ in the mucous and half-digested intestinal contents, although the experiment eventually proved perfectly successful. Of course the difficulty of testing the result is a thousandfold increased where only a very small number of Trichinæ have been administered. In the sixteen remaining cases the results appeared to have been fully ascertained; and out of these, nine were perfectly successful. The "negatives" comprised three sheep, two dogs, one pig, and a mouse. The "positives" embraced four dogs, two cats, one pig, one guinea-pig, and a hedgehog. At all events, at least one-half of the experiments on mammals yielded positive results, which, considering all the circumstances of the case, is by no means unsatisfactory. Carnivorous mammals, and especially those which subsist on a mixed diet, appear to be most liable to entertain Trichinæ; nevertheless it is quite possible to rear flesh-worms in herbivora. Pagenstecher and Fuchs succeeded in rearing muscle-Trichinæ in a calf; and they found three female intestinal Trichinæ in a goat, but, apparently no muscle-flesh-worms, although twenty-seven days had elapsed since the first feeding with trichinized rabbit's flesh. In our three sheep no trace of Trichinæ could be found. However, on account of the expense, comparatively few experiments have been made on herbivora; and, therefore, perhaps, it is as well not to speak too positively from the data already afforded. There is really no practical need for any further experiments with this species of parasite; but it is quite clear that, in their natural state, herbivorous mammals can seldom have an opportunity of infesting themselves, whilst the reverse is the case with swine, carnivorous mammals, and ourselves. Because many quadrupeds may become trichinous, it does not follow that all mammals are liable to be infested. In the case of other parasites (as with the common fluke) we find them limited to a larger or smaller number of hosts; whilst, on the other hand, in not a few cases, the territory occupied is that of the body of a single species. On this subject I need not dwell; but I may instance as examples of very limited distribution the two most common cestodes liable to infest the human body. Nematodes, again, display analogous peculiarities of distribution; but, looking at the subject in relation to the public health, I have no hesitation in saying that a great deal of unnecessary fear has been created in this country. No doubt the Imperial authority in Russia had good grounds for recently issuing an order prohibiting the importation of pork into that country, since severe endemics of Trichiniasis had occurred in neighbouring German states. In this country, however, ordinary precautions will suffice. English swine are almost entirely, if not absolutely, free from this so-called disease; and not a single case of Trichiniasis in the living human subject has been diagnosed in the United Kingdom. Some twenty or thirty cases have been discovered *post mortem*; and it is highly probable that most, if not all, of these trichinised individuals had contracted the disease, during life, by eating German pork sausages or other preparations of foreign meat.

III.

ON THE REARING OF THE LARVÆ OF TÆNIA MEDIOCANELLATA, BY EXPERIMENT WITH "PROGLOTTIDES."

I ORIGINALLY drew up the following observations which were afterward submitted by Professor Simonds and myself, as a joint communication, to the Royal Society. The experiment here fully described was the first of the kind performed in this country, having been anticipated only by Professors Leuckart and Mosler; the former being the first to rear Cystic Entozoa in the calf, thus producing the diseased phenomena, which he called the "acute cestode tuberculosis."

Neither of us having exhausted certain funds placed at our disposal for scientific purposes (in the one case by the Royal Agricultural Society through the Governors of the Royal Veterinary College, and in the other by the British Association for the Advancement of Science), we united the resources which severally remained to us, and instituted a series of practical experiments in helminthology. The investigations have been, for the most part, eminently successful.

The subject selected for this experiment was a fine healthy female calf, about a month old, living at the time on the milk of its dam. As we were unable to obtain possession of the dam, another cow was procured as a foster-mother, and the calf was placed with her in order that it might receive a proper supply of milk in the natural way. This plan was preferred to that of obtaining a weaned calf, as being better calculated to preserve the health and strength of the young animal. In the course of a few days the two animals became perfectly accustomed to each other, the calf taking nourishment as often as was requisite.

On the 21st of December, 1864, we administered to the calf eighty mature proglottides of the *Tænia mediocanellata*, mingled with a little warm milk in the form of a draught. The potion was taken readily, and the worm-joints probably entered the stomach in a perfect and unbroken condition. No alteration was made in the subsequent management of the animals, but a careful daily watch was kept upon the calf.

For some time no indications were perceived of disturbed health; but on the 6th of January, 1865 (the sixteenth day after the experiment), a careful observation showed that the animal, although lively (and taking its milk, and likewise some hay with undiminished appetite), was nevertheless suffering from some persistent cause of irritation. It would often be nibbling at its legs and other parts of its body, and trying with its mouth and tongue to get at places which were beyond its ordinary reach. It would also frequently rub itself against the manger and sides of the loose box in which it was confined. Desisting from this, it would arch its spine and stretch out its hind limbs in an altogether unusual manner. It would also strain itself repeatedly, at such times voiding either urine or fæces, or occasionally both in small quantity. There was, however, no expression of suffering in the countenance, no disturbance of the breathing or of the circulation, no injection of the visible mucous membranes, no alteration of the temperature of the body, no "staring" of the coat, nor rigors; in short, no indication of anything seriously wrong. These symptoms continued throughout the next day with little variation; on the third day they had nearly passed away, and by the fourth had entirely disappeared.

On the 25th of January, 1865, just five weeks after the first worm-feeding, two hundred more of the mature proglottides of

Tœnia mediocanellata were administered; but one hundred of these worm-segments had been previously immersed in a weak alcoholic solution, strong enough, it was feared, to destroy the vitality of their contained eggs. The other hundred proglottides were in beautiful condition, and for the most part appeared to be thoroughly mature. Again the calf took the feeding readily, and little or no force had to be employed in holding it during the administration. However, directly on being loosed, it was observed to show some symptoms of distress in the breathing, accompanied with trembling. The feeding took place at 3 P.M., and as the night promised to be cold, it was placed with the cow in a closed and warm stable. On the following morning, it was noticed that the tremors had somewhat abated, but the animal was evidently dispirited, and would every now and then grind its teeth as if in pain. Its appetite was much diminished. By the next day, however, all these diseased symptoms passed away, and the animal recovered its ordinary healthy aspect.

On the 1st of February, the seventh day succeeding the second worm-feeding, there was a decided return of the nervous irritability; but in a day or two these symptoms again declined. Nevertheless the animal was not quite right; the coat began to lose its natural and glossy appearance, and there was an evident loss of flesh.

Feb. 8th.—A marked change for the worse has taken place. The animal is dull and dispirited; refuses all food excepting milk, and of this takes but little; it arches the back frequently, and stretches the limbs in a peculiar manner; the breathing and the pulse have increased, and at intervals slight tremors are observable, more particularly of the muscles of the neck and shoulders.

Feb. 9th.—All the unhealthy symptoms are more marked. The pulse numbers 120, and the breathing 35 in the minute. The tremors are more continuous, and the condition of the animal is fast declining.

Feb. 10th.—Still worse. The calf is so ill that we fear a fatal result. It takes little or no notice of the cow, and cannot be induced to suck. The eyes have a peculiar staring expression.

Feb. 11th.—The severity of the symptoms has somewat abated this morning. The animal is rather more lively, and will now and then take a little milk. The breathing and pulse, however, remain rapid. The tremors, though still frequent, have diminished in intensity. Towards the after part of the day the improvement became more marked; therefore, instead of destroying the animal (as we had purposed in the event of its becoming much worse), we resolved to satisfy ourselves, by other means, as to whether the above symptoms were really due to parasite-invasion. Accordingly, a small portion of the right sterno-maxillaris muscle was removed by operation, and this fragment of the flesh, although weighing only twenty-two grains, revealed the presence of three imperfectly developed cysticercus-vesicles. Each was about the size of a pin's head, but they displayed no trace of calcareous corpuscles, or of cephalic formation in their interior. On the assumption (afterwards, however, found to be erroneous) that all the muscles of the body might be similarly affected, and to the same extent, it was at the time calculated that the animal "entertained" some 30,000 of these artificially introduced "guests."

Feb. 12th.—A further improvement has taken place, but the animal is still dispirited, the pulse and breathing continuing abnormally rapid. The eyes are less staring.

Feb. 13th.—Improvement continues; breathing less rapid; the tremors have disappeared.

Feb. 15th.—Pulse diminishing; breathing nearly normal; appetite good.

Feb. 22nd.—Convalescence perfectly re-established.

Throughout the remainder of the month of February, and during the whole of March, the calf continued to maintain complete vigour, and, indeed, gained flesh so rapidly, that at the beginning of April it might readily have been sold to a farmer, to a butcher, or to a cattle-dealer, as a thoroughly sound and thriving young beast. The time having, however, arrived for determining the result of the experiment, the calf was slaughtered on the 3rd of April, by division of the right carotid artery. The operation was performed by Mr. Pritchard, who also, during the subsequent *post-mortem* examination, rendered us essential service. As before, so after its death, all present remarked the particularly healthy aspect of the animal, there being no external indications by which the most practised professional eye could have discovered the existence of internal disease. But for our previous trial, we should ourselves have been doubtful of finding any Entozoa within the flesh.

Immediately after the first incision along the median line of the thorax, a solitary Cysticercus came into view, many others successively displaying themselves as the integument was being raised and dissected from off the left side of the carcase. No person in this country having hitherto witnessed such a demonstration as now followed, I may perhaps be permitted to express the natural feeling of astonishment which all shared on thus beholding hundreds of larval cestode parasites in the flesh of an animal not usually considered capable of harbouring "measles" after the fashion of swine.

Examined individually, the larvæ were enclosed in oval sacs, whose transparency permitted us to see, at or near the centre of each vesicle, internally, a minute white spot, representing the so-called receptaculum capitis. On subsequent rupture of the cyst, a microscopic examination of the contained larva revealed the ordinary characters of the Cysticercus which produces the *Tœnia mediocanellata.*

Speaking generally, it may be said that the connective tissue and cellular aponeuroses were very feebly invaded; but in certain situations, such as those occupied by the linea semicircularis and fascia lumbaris, several vesicles were closely associated; moreover, as regards the muscles themselves, extensive parasitic invasion was prevalent only in the more superficial layers. It was likewise noticed, as obtains in the parallel case of Trichina, that the larvæ were disposed in the longitudinal direction of the muscular fibres, being at the same time more numerously grouped towards the points of osseous insertion or of aponeurotic attachment. Not a few large vesicles had inflamed and suppurated, the cysts being occupied internally by a thick green-coloured deposit.

Referring to the left side only, we noted that all the breast-muscles (pectoralis major, p. transversus, and p. anticus) were much infested, but scarcely so fully as the more superficial panniculus carnosus. In the latissimus dorsi and trapezius the cysts were very numerous, rather less so in the combined levator humeri and sterno-occipitalis, somewhat fewer in the rhomboideus brevis and rhomboideus longus, and exceedingly scanty in the superior part of the scalenus, the remainder of this last-named muscle being entirely free. The lateralis sterni contained none; neither were any observed in the abdominal region of the serratus magnus, but several vesicles were lodged in the superficial cervical portion of this muscle. Not a few existed in the upper part of the complexus major and in the minor, some also occurring in the longissimus dorsi; yet none were observed in the spinalis dorsi, in the superficialis costalis, or in the diaphragm.

Turning towards the neck-region, we found them abundant in the sterno-maxillaris, considerably less so in the splenius, only one in the hyoideus, several in the sterno-hyo-thryoideus, but none in the longus colli. All the other deep-seated muscles of this region, including the obliquus capitis superior and inferior, as well as the rectus capitis posticus major and minor, appeared free from any trace of the vesicles. On the other hand, all the superficial muscles of the face, such as the retractor anguli oris, orbicularis oris, and levator palpebrarum, gave abundant evidence of their presence, the vesicles being particularly numerous at the outer part of the massetus externus. In like manner their presence was only less strongly indicated in the muscles of the eyeball, such as the obliquus inferior, adductor and retractor oculi, also in the depressor oculi, one "measle" being placed between the tendon of this last-named muscle and the sclerotic coat. The ball of the eye contained no vesicles. A few were remarked in the substance of the genio-hyoideus and other muscles supplying the tongue; but the lingual organ itself appeared to be entirely free.

As regards the anterior extremity, we found the Cysticerci very numerous in the teres externus and abductor humeralis, being scarcely less abundant in the spinatus anticus and posticus. They were likewise prevalent in the front part of the triceps extensor brachii, but altogether wanting behind and in the deeper portions of this muscle. A few were remarked in the flexor brachii, whilst the subscapularis, teres internus, and coraco-humeralis failed to reveal any. They were very abundant in the flexor metacarpi externus, less so in the flexor metacarpi medius, and comparatively scanty in the flexor metacarpi internus. The lower part of the combined flexor perforatus and perforans shewed a few, several being likewise present in the accessorius ulnaris. They were rather more abundant in the extensor metacarpi magnus, also in the extensor et adductor digitorum, likewise in the extensor digiti externus, and scarcely less so in the extensor metacarpi obliquus; yet none could be discovered either in the anconeus or in the humeralis externus.

Over the haunch, and throughout the surface-flesh of the left hinder limb, the Cysticerci were particularly abundant, being numerous in the gluteus maximus, in the tensor vaginæ femoris, and most especially in the large triceps abductor femoris. They were little less abundant in the vastus externus, and in those limited portions of the gastrocnemius externus and internus which come near the surface. A few vesicles were observed at the subcutaneous posterior section of the ischio-tibialis, also in the outer part of the biceps rotator tibialis and rectus femoris; yet none were noticed either in the gluteus internus and gracilis, or in the vastus internus and sartorius. In the flexor metatarsi and extensor pedis they were rather numerous, but, at the same time, comparatively scarce in the peroneus and flexor pedis perforans. Lastly, none were detected in either the psoas magnus or psoas parvus.

With the exception of the heart, none of the viscera showed Cysticerci, the lungs, liver, kidneys, spleen, and thymus gland being absolutely free; neither were any discovered in the brain. In short, it may be stated that the internal organs of the body generally were perfectly healthy; and even as regards the heart itself, the rather numerous vesicles found there displayed only a very incomplete development. At first they looked as if they might belong to a separate swarm-brood; but a careful microscopic examination disproved this notion, and, at the same time, revealed some curious facts. In the heart none of the vesicles had attained one-third of the size of those prevalent in the muscles, yet their age was doubtless the same; for although none of those examined displayed a well-formed head with the characteristic and normal number of suckers, yet one vesicle was found to possess three suckers, another having two suckers, and a third only a single sucker (see Fig. 1, p. 28). Most of the vesicles were entirely suckerless, whilst those which had them showed other indications of abnormality. The suckers themselves were not perfectly formed, in most cases, and there were commencing signs of calcareous degeneration. In some instances, the entire contents of the vesicles appeared to have been absorbed, leaving only faint white spots to indicate the situations where the cysts once were. Such, at least, is my interpretation of the phenomena observed; and, in this relation, I have further to remark that the heart-cysts were not merely found at the surface of the organ, but were dispersed throughout its substance, one or two of the better-formed vesicles being lodged within the septum ventriculorum.

Only three experiments of this kind have been previously performed on the calf; namely, two by Leuckart, and one by Mosler. In two of these instances the experimental animal perished, whilst in the other case, as in our own, the creature barely escaped with its life. To our animal we administered a larger number of proglottides than had been given even in Mosler's case; but, probably in consequence of the embryonic immaturity of the contents of many of the eggs, we did not get that fatal result which otherwise would inevitably have followed from a larger migration of the cestode-progeny. We believe that by far the greater proportion of the "measles" resulted from the second worm-feeding, in which case they would have come from the hundred proglottides not subjected to the action of alcohol. Although the characters presented by the earlier developed morbid symptoms, as well as the time of their accession, induce us to attribute the diseased phenomena to the larvæ set free by the first "feeding," yet it is clear, from the feebleness of the symptoms manifested, that only a very inconsiderable number of embryos can at that time have entered on their wanderings. In the second "feeding," however, the case is very different; for here all the circumstances connected with the subsequent marked disturbance of the animal's health point unequivocally to the development of that peculiar form of parasite-disease designated by Leuckart as the "acute cestode tuberculosis."

From the number of young vesicles present in the minute portion of muscle removed by operation from the living animal, I had publicly announced my belief that we might ultimately find 30,000 Cysticerci developed in this calf; but as the larvæ were afterwards found to be almost entirely confined to the superficial muscular layers, it turned out that the calculation was considerably beyond the mark. Nevertheless, from *post-mortem* data, we calculated that there were from seven to eight thousand "measles" present, 130 vesicles having been counted at the surface of a single muscle.

IV.

FURTHER OBSERVATIONS ON THE LARVÆ OF TÆNIA MEDIOCANELLATA, WITH REMARKS ON CYSTICERCI FROM MUTTON.

In the foregoing observations I have made allusion to the incomplete development of the measles in the heart of the calf which formed the subject of our first experiment. The facts noticed at the time of dissection were so peculiar, that I purposely reserved a more detailed account of them for some future occasion. Up to the present time, however, my notes on this head, together with many others, have never been made use of; and though, even now in a necessarily fragmentary condition, they are, I think, sufficiently important to be placed on record.

According to my MS., the left side of the heart of the calf displayed about twenty rudimentary measles, not one of which had advanced in development sufficiently to show any trace of head or sucker. Deeper within the substance of the wall of the left ventricle, and in the septum, similar abortive formations were rather more developed. Thus one otherwise well-formed but small vesicle, measuring $\frac{1}{10}''$ from the upper part of the septum, showed a minute calcareous particle in its centre; but there was no sucker. In another similar cyst there were two irregularly-rounded concretions, indicating the situations where two suckers had commenced developing. One of the most perfectly developed of these abortive formations was the Cysticercus which I have here drawn (Fig. 1). It was obtained from the substance of the wall of the left ventricle; the "measle," divested of its cyst, measuring about the $\frac{1}{14}''$. In this case there was one tolerably well-developed sucker (*a*), whose cavity was partly occupied by calcareous matter (*b*). The diameter of the sucker was less than $\frac{1}{30}''$. There were indications of two other suckers, with corresponding patches of calcareous deposition (*c*, *c*). The ordinary corpuscles (*d*, *d*), which I have elsewhere termed "sclerous" particles (to distinguish them from morbid deposits), were as abundant as they usually are in healthy measles. The so-called neck of the Cysticercus (*e*) was tolerably well-formed, its characteristic transverse foldings being well seen through the delicate, transparent, and closely applied caudal vesicle, which, as usual, enclosed all the other structures. I have recorded these additional facts, not merely on account of the pathological significance which they collectively present, but in order to contrast them with the results which I obtained in another experiment, where the natural process of cure was observed.

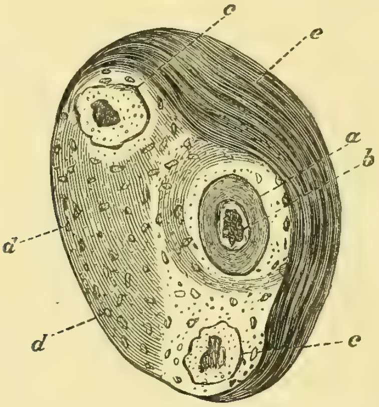

Fig. 1.—Imperfectly developed "Beef-measle" from the heart of a Calf. (× 30 diam.)—Original.

Where the measle has once attained its perfect development, its subsequent calcareous degeneration is a comparatively slow process, and the calcareous mass resulting is naturally larger and more compact. In the 17th Volume of the "Transactions of the Pathological Society" (p. 464), I have described these appearances with tolerable minuteness; but, in a few words, it may be said that, under such circumstances (as those described at p. 34), we only find each separate calcified mass closely invested by its sheath, which latter is partly made up of the original cyst and partly of the so-called connective tissue. As I have been frequently asked to explain the cause of the imperfect development of measles in the heart, I may state, at once, that the subject is involved in much difficulty. I have hitherto supposed that the density of the muscular fibres of the heart, as contrasted with that of the ordinary voluntary muscles, might be sufficient to explain it; whilst the constant and powerful contraction of the organ would certainly tend to restrict the expansion of the young delicate Cysticercus. I still think this the main cause; but, unfortunately, there are instances where the cestode larvæ have entirely overcome this pressure, and have attained a full development. Instances are on record where large hydatids have formed within the muscular substance of this organ in man, and also, I believe, in the lower animals; at all events, the museum of Guy's Hospital contains the heart of a bear which is extensively occupied with Cysticerci. It would be extremely interesting to ascertain to what species of tapeworm these larvæ in the bear are referable. The specimen is a very remarkable one, and apparently unique. I believe there is no published description of it on record. In this connection it is also interesting to keep in mind that small nematodes as, for example, Trichinæ, though they enter the substance of the heart, will not rest and develope there; but many of the larger kinds (species of Ascaris and Prosthecosacter) will freely take up their residence within the ventricles, and attain individually a considerable size. The subject is worthy of further investigation, from whatever point we may choose to view it; but the facts at present made known are too scanty to enable us to arrive at any very definite conclusions.

For convenience sake, I think it desirable to distinguish the larvæ of our various cestodes by different names. Thus, I have been in the habit of recognizing the above described larva under the name of *Cysticercus bovis*, or the "veal and beef measle." This distinguishes it from the more commonly known *Cysticercus* (telæ) *cellulosæ*, or "pork measle," and also from a third measle, which I believe to be distinct, and to which I have given the name of *Cysticercus ovis*, or "mutton-measle" (Fig. 2). It would, undoubtedly, be also better to recognize the pork-measle under the title *Cysticercus suis*.

In the Appendix to my small work on the "Tapeworms" liable to infest the human body, and in the 18th Vol. of the "Transactions of the Pathological Society," I have referred, without particular description, to the existence of this probably distinct form of cestode larva derived from mutton. Since the parasite may acquire more importance when better known, I have here, provisionally, at least, given it the above distinctive name; which, with the few additional details here offered, may lead to the determination of the probable source of its adult representative. The measle having been removed from its cyst, and the caudal vesicle being detached before I had an opportunity of inspecting the specimen, its size could not be accurately ascertained. Probably

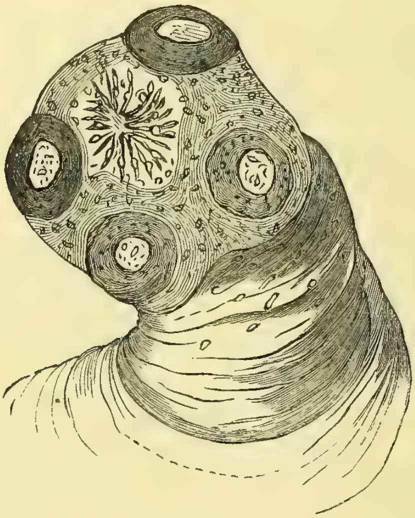

FIG. 2.—Head and neck of a "measle" removed from the centre of a mutton chop. Mr. Heisch's specimen. (× 40 diam.)—Original.

it was much smaller than ordinary pork-cysticercus. The head measures $\frac{1}{30}''$ in breadth, and is armed with a double crown of hooks, twenty-six in number, the larger individually measuring $\frac{1}{160}''$. The suckers are four in number, having severally a breadth of $\frac{1}{100}''$. The so-called neck (as well as the head) is abundantly supplied with calcareous corpuscles, being at the same time marked by several transverse rugæ.

On three separate occasions I have noticed small hydatigenous cysts in joints of mutton brought to my own table. Dr. Kirk informs me that he has observed similar appearances. My specimens were all calcified; but the one received by me from Mr. Heisch was, as may be seen by the accompanying figure, an almost perfect example of an armed Cysticercus.

In this connection I may mention that I recently received from Dr. Prior part of a purchased Westphalian ham which was literally swarming with "measles." From a portion, weighing about three drachms, I removed upwards of twenty Cysticerci. The measles appear to have been pretty equably distributed throughout the ham; nevertheless, I understood that the tradesman who sold it did not scruple to eat a hearty meal off this diseased meat in order to satisfy his customers as to its value. Of course, if well cooked, no harm could possibly result; nevertheless, the mere exhibition of such infested flesh should be sufficient to excite disgust in the minds of most people.

V.

ADDITIONAL SUCCESSFUL EXPERIMENTS RESPECTING TÆNIA MEDIOCANELLATA, T. SERRATA, T. MARGINATA, AND T. CŒNURUS.

The following experiments may be regarded as a continuation of the foregoing. The procuring and selecting of the parasitic materials usually devolved upon myself; whilst, on the other hand, Professors Simonds and Pritchard commonly performed the administrations. Other persons frequently rendered assistance during the "feedings." Mr. Simonds also conducted certain experiments independently; but only those for which I may be considered as exclusively responsible are here enumerated and described. A second calf was experimented on, but as I had not an opportunity of examining its flesh myself, I am by no means satisfied that the results were negative. The animal, I was informed, died from an attack of rinderpest about six months after the first "feedings" were administered.

The second successful case in which I took part was that in which a fine healthy Dutch heifer formed the subject of experiment. On the 3rd of March, 1865, this animal was made to swallow ninety proglottides of *Tænia mediocanellata,* given in tepid water. On the 15th of the same month, 108 "joints" were also administered. On the 5th of April, another hundred segments were conveyed to the stomach; and, for a few days subsequent to this last feeding, the animal became rather restless, bellowing occasionally. As no other symptoms followed, I made, on the 13th of April, a very careful selection of 200 ripe proglottides from tapeworms which

I had only that very day received from Dr. Fleming, of Birmingham. During several succeeding days the restlessness appeared to increase slightly, and the bellowing likewise continued. Moreover, there were certain peculiarities of manner which convinced Mr. Simonds (who watched the animal almost daily) that we had here, at least, a feeble development of those symptoms of the "acute cestode tuberculosis" which were so strongly marked in our first experiment on a calf. There was the same vacant stare, a dull expression of the eye, slight arching of the back, and stretching the limbs. However, the heifer never lost her appetite; and, strange to say, whilst all the cattle near her were attacked by (and most of them died of) the rinderpest, she entirely resisted its invasion. In about a week all the measle-symptoms passed off, and in course of time the animal attained the proportions and aspect of a large, healthy, three-year old cow. It was not until the expiration of rather more than a year from the time of our first feedings, namely, on the 4th of April, 1866, that the beast was slaughtered. With Mr. Pritchard's assistance, I made a very careful dissection and examination of the beef thus obtained; nor was it until I had subjected the muscles for many minutes to a very close and careful scrutiny (with the aid of a pocket-lens) that I succeeded in detecting evidence of the successful character of our experiment. The result was most interesting, especially since none of the hitherto recorded experiments (either by ourselves, or those previously instituted by Leuckart and Mosler) had extended over such a period of time. Here the only indication of the presence of measles was shown by the existence of extremely minute calcareous specks, larger, it is true, but by no means so conspicuous as ordinary Trichina-capsules. They presented the aspect of sparsely-scattered yellowish points, without any definite outline, or any other character likely to catch the eye. It is even difficult to see them in sections of the flesh which I have preserved in order to show them. Microscopic examination affords evidence of the remains of a small cyst; but all trace of the measle itself is entirely lost. Each Cysticercus had become, as it were, resolved into a more or less amorphous, solid, friable, crystalline particle, whose true characters (as presented to the naked eye) were obscured by a closely investing and remarkably contracted cyst, the external surface of the latter becoming insensibly blended with the ordinary intermuscular connective tissue. By a little care, however, the calcareous particles could be perfectly isolated from their cysts. They were numerous, and, owing to the deeper colour of the muscular substance, most easily found in the diaphragm. In other muscles they were, perhaps, equally abundant, but it was a great labour to find them. Assuming them to have been pretty equably distributed throughout the muscular system, there could not have been less than 12,000 of these degenerated measles in the animal. I have no hesitation in saying that, if there had been 12,000,000 of these measles, no butcher would ever have noticed them; but, fortunately, in this condition their ingestion could do no possible harm. In point of fact, the flesh of the animal has since been entirely eaten; and healthier beef I never saw. Even in their perfect, non-degenerated state, the beef measles are readily overlooked; and, until recently, no person besides Mr. Simonds, Mr. Pritchard, and myself, and those who assisted us, had ever seen them in this country. The experiment now recorded is the first in which the natural process of cure has been traced; and it is of great practical importance, inasmuch as it proves to demonstration that a period of ten or twelve months is fully sufficient to ensure the natural death (by calcareous degeneration) of the smaller tapeworm-larvæ which reside in cattle. This is a positive contribution to our knowledge of the life-economy of these smaller Cysticerci, and it serves to fix the period of their larval activity. All the Entozoa, in their juvenile stages, whilst occupying the flesh of man and animals, are liable to be affected by this law of calcareous degeneration; but the actual time required to bring about the death of the parasite varies considerably in different species.

Tænia serrata.—Exp. 1. Three examples of the pea-shaped hydatid (*Cysticercus pisiformis*) were removed from the abdominal viscera of a recently killed rabbit. Two of them were rather more perfectly developed and larger than the third. The rabbit harboured no others. These three cestode larvæ were administered, on the 25th of January, 1865, to a healthy puppy, reared at the Veterinary College, and nearly twelve weeks old. Five days subsequently, namely, on the 30th of the same month, the puppy was destroyed. In the alimentary canal I found three young *Tæniæ*, and three only. Two of them were severally about one inch in length, the third being a trifle shorter, and not quite so large. These sexually immature tapeworms presented all the true characteristics of *T. serrata*, and their degree of development was in exact accordance with my previous experiences in this relation. The more feeble development of the third tapeworm proved its genetic connection with that larva which, at the time of the worm-administration, was noticed and recorded as being rather incompletely developed. The experiment was a perfect success.

Exp. 2. On the 25th of January, 1865, a second rabbit was destroyed, for the purpose of procuring additional tapeworm-larvæ. In this rabbit I only found one solitary and perfect *Cysticercus pisiformis*—a somewhat unusual circumstance. Mr. Simonds placed this larva in a small piece of paper, and, in the form of a bolus, gave it to a little puppy which belonged to the same litter as the former, being readily distinguished by its black ears. We did not destroy this whelp until the 7th of the following February, thus allowing a period of thirteen days to elapse for the development of the solitary *Tænia serrata* which we desired to rear from the Cysticercus. Mr. Simonds, as usual, requested me to examine the alimentary canal; and I had the satisfaction of removing the solitary *Tænia serrata* we had thus successfully reared. It was just six inches in length, showing the same correspondency as to growth, in respect of time, which my previous and independent experiences with the artificial method of rearing this parasite had invariably supplied. The proglottides were still immature, but the cephalic development was in all respects complete.

Tœnia marginata.—On the 28th of January, 1865, Mr. Simonds removed fourteen specimens of the so-called slender-necked hydatid from the omentum and surrounding viscera of a hogget. Five of these large Cysticerci (*C. tenuicollis*) were administered to the mother of the two whelps above referred to. They were swallowed entire, without any additional material. This dog was killed on the 7th of the following February, thus allowing only ten days for the development of the corresponding adult tape-worms. As usually happens in all old dogs, we found in the intestinal passages many examples of the extremely common cucumerine tapeworm (*T. cucumerina*); but these, of course, could have no genetic relation to the tapeworm-larvæ, which latter were already known to be the offspring of an entirely different species of cestode parasite. Our experiment, indeed, was a perfect success; for, in addition to the cucumerine tapeworms (of which there were fifteen mature specimens of variable size and growth), I found in the duodenal portion of the intestinal canal five young and sexually immature examples of the *Tœnia marginata.* These were of uniform size, and severally one inch in length. Not a shadow of doubt could be entertained as to their relation to the five Cysticerci which had been administered. Their specific characteristics, uniform development, degree of growth, and separate location in the canal, pointed unequivocally to the source whence they had been derived. Here again, therefore, previous experiences received abundant confirmation.

Tœnia cœnurus.—Exp. 1. On the 15th of March, 1865, Mr. Simonds received (from Messrs. Caudwell, of St. Neots) the head of a "giddy" sheep which had been killed two days previously. On examination the brain was found to contain a perfect polycephalous hydatid *(Cœnurus cerebralis)* which, it was estimated, supported about 150 scoleciform processes, or larval tape-worm-heads. It was removed entire, and given by Mr. Simonds to a dog, which swallowed the parasite readily in its unbroken condition. Only five days subsequently, namely on the 20th of March, the experimental animal was destroyed; and here again a complete success attended our experiment. A careful examination of the alimentary mucus enabled me to extract a large number of extremely minute tapeworms, of so small a size that they were scarcely visible to the naked eye. Though only the heads and necks were developed, their characters corresponded with what was hitherto known of the head and neck of *Tœnia cœnurus*, to which species they were undoubtedly referable. Their number appeared to correspond precisely with the number of scoleces attached to the common "gid" vesicle; but no attempt was made to collect every specimen, as that would have involved an immense amount of unnecessary labour. All trace of the vesicle common to the colony of "heads" had disappeared, the necks of the scolices, detached by digestive action, having become rounded off and more or less pointed (according to the degree of contraction shown by each specimen while under microscopic examination).

Exp. 2. On the 6th of April, 1865, a similar administration, with a brain-hydatid furnished with about 100 cephalic processes, was performed on a stray dog. Two days subsequently, however, the animal was claimed by its rightful owner, and we had therefore, in this instance, no opportunity of ascertaining the result of our experiment.

Exp. 3. On the 25th of April, Mr. Simonds received (from Mr. Mackinder, of Peterborough) the head of a sheep affected with "gid." The brain was found to contain three *T. cœnuri*. One of these, furnished with numerous heads, was given to a large half-bred lurcher dog. On the 16th of the following May, the animal was destroyed, thus permitting twenty-one days for the development of the slow-growing *Tœnia cœnurus*. As too often happens in the case of old dogs, the digestive passages were found loaded with a great variety of tapeworms; nevertheless it was here again quite easy for us to distinguish between the parasites which had been introduced by our experiment and those which had gained access to the canine "bearer" without our aid. Thus there were found in this "lurcher" several examples of the large *Tænia marginata*, six or eight specimens of *Tænia serrata*, and a few examples also of *T. cucumerina*. There were likewise some half-dozen nematodes *(Strongyli)*. In addition to all these, however, there were a multitude of small tapeworms (of the species *T. cœnurus*), the longest of which did not exceed one inch and a half in length, sexually immature, and manifestly corresponding with the numerous scolices artificially introduced. Again, therefore, despite the inconveniences always liable to attend administrations of this kind on old dogs, we had abundant proof of the success of our experiment.

Exp. 4. On the 25th of April, 1865, another of the two remaining *T. cœnuri* just mentioned was given by Mr. Simonds to a smaller dog. This hydatid was also well furnished with cephalic processes (or larval tapeworm-heads). In this case the experimental animal was not killed until more than two months had elapsed from the time of the worm-administration. On the 29th of the following June we made the necessary examination. Again we were successful. The intestinal canal contained large numbers of the *Tænia cœnurus*, there being no other kinds of Entozoa present. The experiment was therefore even more satisfactory than the previous one. The largest specimens measured about eighteen inches in length; but when I examined their proglottides, the contained eggs were still not quite perfectly developed. The primitive yelk-sacs and superfluous granular yelk masses were very conspicuous, but the true chorional envelope was only in the act of forming. The swallowing of the ova in this imperfect stage would lead to no result. Probably another week or ten days would have sufficed to render all these *Tæniæ* sexually mature.

Exp. 5. On the 8th of July, 1865, a large *T. cœnurus* was given to a terrier, which was also subsequently fed with trichinous flesh.

This animal died on the 2nd of August of the following year, but unfortunately neither Mr. Simonds nor myself had any opportunity of examining the contents of its viscera. A portion of its muscle-flesh was sent to me for microscopic examination, and this I found to contain encysted *Trichinæ.*

In addition to the above, several other experiments were performed with the larvæ of *Tœnia solium* and *T. echinococcus.* In these instances we were unsuccessful. The same negative result followed the attempts to rear the larvæ of *Tœnia mediocanellata* in the sheep. It is not impossible that the armed Cysticerci which I have described as occurring in mutton may turn out to be referable to a species of cestode infesting the higher carnivora; nevertheless, I entertain a well-grounded suspicion that the human "host" is liable, not only to entertain the beef and pork tapeworms, but likewise a third form derived from mutton. I believe the smaller varieties of the so-called *Tœnia solium* answer to this hitherto unrecognized cestode.

VI.

ON THE NATURE OF PSEUDENTOZOA FOUND IN DISEASED AND HEALTHY CATTLE.

In the year 1865 the public mind of this country was thoroughly roused to a sense of the dangers consequent upon eating diseased meat. The panic arose chiefly from the severe outbreaks of Trichiniasis previously reported from Germany. During the excitement which prevailed at the time of the rinderpest, all sorts of erroneous notions took possession of the popular mind, and these errors were unfortunately stimulated by the imperfect helminthological communications of some who undertook to instruct the people. In the month of January, of the following year, I published a few observations, the purport of which was to show not only that certain microscopic organisms, found in animals dying from cattle-plague, had little or nothing in common with true Entozoa, but that they were harmless "parasitic Protozoa," possessing more or less striking vegetable affinities. About a week previous other highly interesting researches on these so-called cattle-plague bodies were published by Professor Beale, but I did not meet with any person who had possessed at the time any adequate idea of the extent of the literature of the subject. In fact those who first saw these bodies thought they had stumbled upon organisms entirely new to science. I showed that similar or analogous organisms were to be met with in a great variety of animals, and likewise in the human body. They had been described under a variety of titles, such as worm-nodules, worm-nests, egg-sacs, eggs of the common fluke, young "measles," corpuscles produced by muscular degeneration, psorospermiæ, stages of growth of gregarinæ, amœboid bodies, and so forth. In so far as the higher animals were concerned, Dujardin was the first to describe these structures in the mole.* This animal, however, having been fed upon earth-worms (whose perivisceral cavities were previously known to be constantly liable to harbour such parasites), there was no difficulty in accounting for the source of the psorosperms. In 1853, Hessling discovered psorospermial sacs in the muscular substance of the heart, not only of the ox, but also of the sheep and roe.† By him they were regarded as evidences of muscular degeneration. About ten years previously Miescher is said to have found similar bodies in the muscles of the mouse.‡ In 1857, Rainey described precisely similar structures taken from the flesh of swine; and, in his able memoir, he went so far as to maintain that these bodies were neither more nor less than the early stages of development of the common pork-measle.§ This view is still, I believe, maintained by Mr. Rainey; but, in support of his theory, I am not aware that he can reckon upon the aid of any helminthological writer of distinction. I may add, however, that for accuracy of description and detail, no communication either past or present is likely to surpass the one contributed by this able microscopist. In the year 1858, Gubler wrote a most important paper bearing on this subject, in which he related a case where twenty cysts existed in the human liver.‖ These sacs were of great size, mostly as large as a hen's egg, one of them being some six inches in diameter. Naturally enough, the largest was, during life, diagnosed to be that of an ordinary hydatid. Their nature, however, proved to be very different; for, on evacuating their contents (post mortem), they were found to harbour enormous quantities of minute corpuscles strictly analogous to those obtained from the ordinary psorospermial sacs. Gubler believed he had stumbled upon masses of eggs of *Distoma hepaticum*; but, to show how fallacious this notion was, it may be mentioned, that whilst the eggs of the common fluke measure as much as $\frac{1}{180}$ of an inch in diameter, the corpuscles in question were only some $\frac{1}{1500}$ of an inch long. Shortly after Gubler, similar bodies from the human liver were described by Virchow;[*] and in 1862, the subject was followed up by Dr. Dressler, of Prague.[†] Dressler, also in the human liver, found a number of pea-shaped bodies, the milky contents *(breisubstanz)* of which displayed a multitude of the characteristic corpuscular elements just referred to. These particles, already considered as equivalent to, if not identical with, the so-called pseudo-navicellæ of gregarinæ were now encountered by a variety of independent observers. From time to time Leuckart noticed these bodies in various animals, but with a caution natural to him he remarks:—"Concerning the nature of these formations I will not decide. To be candid, however, it appears to me to be in no way made out, whether the psorospermiæ are to be considered as the result of a special animal development, whether they, like pseudo-navicellæ, are the nuclei of gregariniform productions, or whether they are the final products of pathological metamorphosis."[‡] Leuckart found these organisms in the intestines of a trichinised dog, also in a sheep and a pig severally fed with Trichinæ, in the muscles of another pig fed with psorosperms, and likewise, I believe, in the liver of various rabbits. He remarks that in swine these parasites, as compared with measles, are much more abundant. They were present in five of eighteen pigs, and also in two out of four sheep, whose flesh was specially examined by him in this relation. Valuable, however, as are the foregoing records, perhaps, in a pathological point of view, none equal in interest the observations of

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* Hist. Nat. des Helm., 1845, p. 643.

† Sieb. and Köll. Zeitsch., 1853, bd. v., s. 196.

‡ Quoted by Leuckart and Siebold.

§ Phil. Trans., 1857, vol. 147.

‖ Mém. Soc. Biol., 1859, p. 657, and Gaz. Méd., 1858, tom. v., p. 61.

[*] Arch. für Path. Anat., bd. xviii., s. 523.

[†] Quoted by Leuckart.

[‡] Die Mensch. Paras., 1863, bd. i., s. 141.

Lindemann at Nischney-Novgorod.* This medical officer discovered psorospermial sacs attached to the hair of a girl who was being treated in hospital for chlorosis. I may remark, in passing, that the sacs in question bear a remarkable resemblance to the bodies which we now find in such abundance, not only in diseased but also in healthy cattle; and it would appear, from Lindemann's observations, that the affection is not very uncommon amongst the people of the locality just named. Curiously enough, in connexion with and attached to the same parasitically affected hairs, Lindemann noticed several moveable gregarinæ; and from this circumstance, in association with other considerations, he was led to believe in the existence of a genetic relation subsisting between the two kinds of bodies. He further expresses his conviction that the people contract the disease, if such it may be called, by washing themselves with water in which gregarinæ abound. Lindemann moreover refers to Lebert as having noticed similar parasites in a case of favus, and concludes that these organisms are of a vegetable nature. His opinion, though not shared by the majority of parasitologists, is nevertheless supported by the views of Robin,† Leydig,‡ and one or two others. Of still higher interest, also, are the observations of Lindemann respecting the occurrence of psorospermiæ in the capsule of the kidney of an hospital patient, who died with Bright's disease. The sacs in this case were remarkably small; nevertheless, their corpuscular contents unequivocally indicated their true nature. The pseudo-navicellæ measured only the $\frac{1}{5000}$ of an inch in diameter. Here, I might pause; yet, besides the above, many other able memoirs have appeared on the gregarinida, with which these bodies appear to be so intimately associated. Amongst the contributions, I would specially refer to those of Dufour;§ J. Müller;‖ Creplin;¶

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* Quoted by Leuckart.

† Les Végét Paras., second ed., p. 291.

‡ Müller's Arch., 1851, p. 221, and Micros. Journ., 1853, p. 206, and Arch. für Anat. u. Phys., 1863, s. 191.

§ Ann. des Sci. Nat., 1837.

‖ Arch., 1841, s. 477.

¶ Müll. Arch., 1842, s. 61.

Kölliker;[*] Keferstein;[†] Stein;[‡] Drummond;[§] Lieberkühn;[||] and E. Ray Lankester.[¶] To these I may add reference to my own previous observations.[**] I doubt if the interesting vegetable organisms described by Professor W. T. Gairdner[††] can be referred to the group of parasites under consideration. At all events, from the foregoing remarks I think it will be seen that these spurious Entozoa, by whatever name called, were first discovered by Dufour in insects, by Müller in fishes, by Miescher in the mouse, by Dujardin in the mole, by Hessling in the larger quadrupeds, and by Gubler in man.

In this connexion, the results of my own oft-repeated examinations may be very briefly stated. In the flesh of cattle, I found psorospermial sacs varying from $\frac{1}{120}$ to $\frac{1}{12}$ of an inch in length, and in that of sheep from $\frac{1}{225}$ to $\frac{1}{80}$ of an inch. The bodies are enclosed in a well-defined transparent envelope, and even under low magnifying powers, their contents exhibit more or less distinct indications of segmentation. In some specimens the segments display themselves as a complete cell-formation, the contents of each individual cell being uniformly granular. Even under the quarter-inch objective, the contained granules are clearly visible, and on rupturing the sac, their peculiar characteristics are at once manifest. Each granule or corpuscle represents a pseudo-navicel, all of them displaying a tolerably uniform size, which I calculated to average about the $\frac{1}{2000}$ of an inch in diameter. Some of the corpuscles were round, others oval, several bluntly pointed at one end, many curved and fusiform, not a few being almost reniform. Under the quarter objective, highly refracting points or nucleoli were fairly visible in their anterior, but on employing the one-twelfth, I made out nothing more respecting the contents of the corpuscles.

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[*] Zeitsch., 1848—49.

[†] Gött. Anzeig., 1862, s. 1608.

[‡] Müll. Arch., 1848, and Ann. Nat. Hist., 1850.

[§] Edin. Physiol. Soc. Rep., June 19th, 1852.

[||] Müll. Arch., 1854, s. 349, and Reich. and Du Bois-Reym. Journ., Sept. 1865, and Micros. Journ., Jan. 1866.

[¶] Ibid., 1866, p. 23.

[**] Proc. Linn. Soc., May 1862, p. 245, and Intell. Observ., 1862, p. 199.

[††] Edin. Phys. Soc. Rep., for March 19th, 1853.

Turning to the more obviously practical aspect of the subject, I have again to remark, that these bodies have nothing whatever to do with the cattle plague. No one, it is true, who has had an opportunity of examining the flesh of any number of animals dying of rinderpest has, so far as I am aware, failed to discover them; yet in one or two isolated instances they appear to have escaped notice, and may possibly not have been present. When it is considered how long it takes us to examine a few grains weight of muscle carefully, it is obvious that the body of a large beast might contain many hundreds, or even thousands, of these spurious Entozoa, without our being able to detect their presence, except by a very prolonged and unnecessary investigation. In the few rinderpest beasts, portions of whose flesh I have submitted to the microscope, I should say that there were not more than one hundred of these bodies in an ounce of meat; but in the heart of a healthy sheep (which I afterwards ate) I calculated there were about a thousand parasites to the ounce, and in the heart of a healthy bullock (which likewise served me for a meal) their numbers were probably rather in excess of those in the sheep. Altogether, at two meals, I could not have swallowed less than 18,000 of these psorospermiæ; yet had they been Trichinæ, I should have hesitated to have dined off this food, however thoroughly well cooked the meat might have been. The fact is, that consumers of beef, mutton, and pork eat these bodies every day, but they take no harm because the parasites in question are not Entozoa in any proper sense of the term. I have known fine healthy beef to be returned by an alarmed customer to the butcher, when it was as good as any other meat in the market. I have examined various other meats such as veal, pork, and mutton, but in none have I found so great an abundance of these falsely so-called Entozoa as in beef which was perfectly healthy and sound. I should say, without exaggeration, that in one case a single ounce of the flesh contained upwards of 2000 parasites.

VII.

ON THE COMPARATIVE PREVALENCE OF DIFFERENT FORMS OF ENTOZOA INFESTING THE DOG, IN RELATION TO PUBLIC HEALTH.

Notwithstanding the rapid advances of Epidemiological Science in general, and of helminthology in particular, few persons are aware how intimately connected are the relations subsisting between man and the domestic animals in reference to entozootic diseases. Whilst our very existence is dependent upon a supply of certain animals, as sources of food and aids to civilization, it can nevertheless be shown that, under certain circumstances, any one of the most valued of our domestic quadrupeds may become an occasion of discomfort, disease, or even death. The truth of this general statement is sufficiently obvious in cases of ordinary accident, and also in those diseases (hydrophobia, for example) whose nature is either doubtful, or which, at the least, cannot be said to have a parasitic origin; but it comes out much more forcibly when we confine our attention exclusively to evils arising from Entozoa harboured by our domesticated animals in their capacity as "intermediary bearers." In these pages I have selected the dog as pointedly illustrating the correctness of the proposition just advanced; but, at the same time, I may add that, excepting, perhaps, the equine quadrupeds, I know of no important domestic animal which is not liable, by the agency of its parasites, to inflict on the human body one or other of the injuries just referred to—namely, discomfort, disease, or death.

I may also remark, in passing, that all our researches, and more especially those of the experimental kind, tend to show how the evils just mentioned may be averted; and many of our investigations, having, in the first instance, a purely scientific object, have materially strengthened the results obtained by other researches having merely a practical aim. It may be said that the two methods should go hand in hand, or, at least, *pari passu*, in order to ensure brilliant results. Already helminthologists have obtained a considerable success; but it is just one of those successes in which the principal promoters are left without reward. Self-imposed tasks of this kind are more or less the prerogative of all the votaries of science, who, at least, have the satisfaction of knowing that they contribute to the public good.

To simplify and limit the subject-matter, I have given below a complete and revised list of all the Entozoa (species, varieties, and larvæ) at present known to infest the dog. In many respects, it is interesting to contrast this, as a whole, with the rather more extended list of human Entozoa recorded in this work (Part II.: Special Helminthology; p. 146); but, as will hereafter be seen, the mutual relations subsisting between certain members of the two series can only be established by a somewhat detailed notice respecting the individual forms. These are as follows:—

1. *Holostoma alatum*, Nitzsch.
2. *Spiroptera sanguinolenta*, Rudolphi.
3. *Dochmius trigonocephalus*, Dujardin.
4. *Trichosoma plica*, Rudolphi.
5. *Trichocephalus depressiusculus*, Rudolphi.
6. *Trichina spiralis*, Owen.
7. *Ascaris marginata*, Rudolphi.
8. *Eustrongylus gigas*, Diesing.
9. *Bothriocephalus latus*, Bremser.
10. *B. cordatus*, Leuckart.
11. *B. fuscus*, Krabbe.
    ,, ,, var. *reticulatus*, Krabbe.

B. fuscus, var. *dubius*, Krabbe.
12. *Tænia marginata*, Batsch.
13. *T. cœnurus*, Kuchenmeister.
14. *T. cucumerina*, Bloch.
15. *T. serrata*, Goeze.
16. *T. litterata*, Batsch.
17. *T. echinococcus*, Siebold.
18. *Pentastoma tænioides*, Rudolphi.
19. *Cysticercus* (*telæ*) *cellulosæ*, Rud.
20. *Filaria trispinulosa*, Diesing. } larval forms.
21. *F. sanguinis*, Cobbold.

The above list, large as it is, might be very much extended if one chose to regard as true species a number of particular forms and varieties described by authors under other names, and severally considered by them to be well marked; but I could show, if it were necessary, that most, if not all, of the forms referred to are in point of fact identical with those here provisionally admitted as distinct. Probably the list is somewhat too extended as it is; yet I purposely refrain from entering at any length upon the exclusively zoological aspects of the question. In other words, I wish it to be understood that, as regards several of the forms here enumerated, I do not pledge myself to affirm that they are specifically distinct; nevertheless, taking them up serially in the order given, I have a few remarks to offer respecting each; and fortunately the end proposed will enable me to restrict my observations within the narrowest possible limits.

1. *Holostoma alatum.*—Speaking generally, flukes are sparingly found in the carnivorous mammalia; therefore that the Trematoda should be represented by a single species in the dog need not excite surprise. Though rare in the dog, this fluke is not uncommon in its congeners, the fox and wolf. Under a variety of names, its structure and relations have been carefully studied; but there is no ground for supposing that its existence is, either directly or indirectly, injurious to man.

2. *Spiroptera sanguinolenta.*—I am not aware that any one has distinctly indicated the presence of this parasite in dogs dying or destroyed in this country; but it appears to be tolerably frequent in France and Germany. I believe it to be identical with the round worm, which is known to be common in China, and not unfrequently to cause the sudden death of its canine host. Some years ago, a manuscript was placed in my hands, giving a detailed account of the ravages inflicted by these parasites; the paper, however, has been irretrievably lost. Professor Bennett, of Edinburgh, has in his possession a Chinese dog's heart which had burst, during life, from the pressure occasioned by a large number of these parasites lodged in the ventricles. One of the specimens presented to me by Dr. Bennett measures exactly ten inches in length. Dr. J. Lamprey has also found "Entozoa in the cavities of the hearts of dogs in China." In the year 1813 a round worm, probably referable to this species, was found in the heart of a dog at Paris; and there is some probability that the microscopic hæmatozoa, first discovered by Grube and Delafond in the blood of dogs, are genetically related to this species. Other remarks upon this point will be found further on.

3. *Dochmius trigonocephalus.*—This small parasite is probably not uncommon in this country; but it is either frequently overlooked, or disregarded on account of its apparent unimportance. It is not likely that the migrating progeny are the source of the verminiferous condition of the blood just alluded to. Its prevalence is certainly very variable in different countries or districts; but the only accurate observations bearing upon this point are those given by Dr. Krabbe in his recent Danish work.* Out of 500 dogs which he had examined (after death) at the Royal

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* "Helminthologiske Undersögelser i Danmark og paa Island, med særligt Hensyn til Blæreormlidelserne paa Island." Af Dr. med. H. Krabbe. Kjœbenhavn, 1865. [The above facts are taken from the Danish work, for a copy of which I am indebted to the distinguished author. Soon after I had, with no small labour, translated part of this treatise, a French edition of this book appeared. Dr. Krabbe has likewise, through M. Blanchard, communicated a résumé of his able researches to the French Academy.]

Veterinary and Agricultural College at Copenhagen, only nine contained this parasite, whilst in 100 dogs dissected in Iceland it was entirely wanting. His experience, as regards its prevalence in other members of the canine race, coincides with that of observers generally; for he found this entozoon in three Danish foxes, and also in a blue or Arctic fox (*Canis lagopus*) which died in Dr. Kjærbolling's menagerie. It is worthy of remark that the last-named animal had originally come from Iceland. The importance of noticing these particulars, and of indicating all the rarer forms of canine Entozoa, will appear in the sequel.

4. *Trichosoma plica.*—This parasite, like the previous species, is much more common in the fox than in the dog; but the possibility of its occurrence in the latter should be borne in mind. So far as I am aware, the only direct proof we have of its liability to infest the dog rests upon the statements of Dr. Bellingham. The circumstance of its not inhabiting the alimentary canal will readily account for its not having been often seen, although it should afterwards turn out to be comparatively frequent in occurrence. The organization of the species has been sufficiently well investigated by Rayer; but its precise genetic relations remain to be cleared up. It is by no means improbable that the progeny of the preceding species, as well as of this entozoon, and of the form next to be noticed, passes through phases of development closely resembling those of *Trichina*. Thus it may happen that an inexperienced observer finding these larvæ, in the act of migrating, in the flesh of any "host," might be induced to conclude that he had discovered examples of the flesh-worm disease, when in truth he had only encountered the offspring of parasites totally distinct. Mistakes of this kind have occurred over and over again in reference to a minute and little-known parasite (*Olulanus*, Leuckt.) which infests the cat; and doubtless nearly all the sexually immature forms of parasites described as new species by their respective discoverers are the offspring only of some of their more or less familiarly known adult representatives.

5. *Trichocephalus depressiusculus.*—This parasite is likewise common to the dog and fox; and though, on the whole, more prevalent in the former, cannot be said to be frequent in either. I have only seen one or two examples. Out of 144 dogs dissected at Vienna, it was only noticed four times; and in sixty-two foxes examined at the same place, not one was encountered. On the other hand, Dujardin found this species present in two out of seven foxes dissected by him at Rennes. It does not appear to have come under Dr. Krabbe's observation in any of the 600 dogs which he examined in Denmark and Iceland. I regret that I retain no accurate data respecting the prevalence of this and several other of the less frequent parasitic forms which I have encountered from time to time in dogs. Until lately, the value of such peculiar statistical records, in reference to our domestic animals, did not fully strike me; but from 1855 to 1864 inclusive I noted down all the parasites encountered in less common "hosts." Part of the fragmentary results thus obtained are recorded in the "Proceedings of the Zoological Society" for 1861.

6. *Trichina spiralis.*—This interesting parasite is probably not indigenous, so to speak, in the dog; but the ease with which it may be transmitted, and the frequency of its introduction by experiment, oblige us now to class the "flesh-worm" with other canine Entozoa. Until lately, it was supposed that *Trichina* might be made to infest any warm-blooded animal; but the experiments conducted by Mr. Simonds and myself at the Royal Veterinary College in London, together with those on a more extended scale, by Drs. Pagenstecher and Fuchs, at the Zoological Institute at Heidelberg, incontestably prove that the so-called flesh-worm, as such, cannot be reared in birds. Having given in the foregoing pages a detailed account of these experiments, I will only again remark that I have repeatedly reared *Trichinæ* in the dog from the flesh of man and animals. Except in a very indirect manner, the dog itself is scarcely likely to communicate the flesh-worm disease to

man; nevertheless, if the flesh of a trichinised dog were eaten by us, the malady would be readily propagated. There would, moreover, be considerable danger in allowing trichinised dogs to roam at large; for the consumption of their flesh (after death) by other animals—such as rats, for example—would convey the disorder to new "hosts," which again might convey it to the pig, and ultimately to man. It has, indeed, been fully proved that, in some instances, swine have been infected by eating dead rats and the decomposing remains of other trichinised animals; and it is quite certain that rats, not previously made the subject of experiment, have been found to contain *Trichinæ* in their muscles. Dr. Krabbe informed me, by letter, that he has discovered trichinised rats in Copenhagen. The same thing has been noticed in Germany. Dogs and cats alike may become infected from this source. Bearing in mind, therefore, the variety of sources whence the dog may obtain *Trichina*, no one need in future be surprised at finding this animal affected with the disease; and, since the malady is so readily transmissible, care should be taken to destroy, thoroughly, all trichinised animal flesh, wherever and whenever encountered. In illustration of the facts above given, I may mention that I have caused *Trichinæ* to be transferred from the flesh of man to a hedgehog, then from the muscles of this hedgehog to a dog, and ultimately from the dog to a pig. It was in this last-named animal that I obtained about 16,000,000 *Trichinæ*—enough to have trichinised half the inhabitants of London, could each individual have been induced to partake of a minute portion of the uncooked flesh. As it was, Mr. Simonds and myself had some difficulty in persuading bystanders that the perfectly healthy-looking flesh had anything the matter with it; and one person actually carried off the heart of the animal as a perquisite. Fortunately *Trichinæ* do not stay in the substance of the heart, although they pass through it; and thus the person who ate part of that heart can by no possibility have sustained injury. Lastly, considering the abundant and satisfactory experiences now obtained by experimental helminthologists, I hold that there is no need for further experiments in this particular relation; from a hygienic point of view they are even undesirable.

7. *Ascaris marginata.*—Of all the parasites infesting the dog in England this species is the commonest. I have met with it in about thirty out of forty dogs dissected by myself and friends. It does not appear to be quite so common abroad: nevertheless, out of 144 dogs dissected at the Vienna Museum, it was present in no less than 104 instances. At Copenhagen, Dr. Krabbe found it present 122 times out of 500, or in twenty-four per cent. of the dogs he examined; but in Iceland, where other forms of canine Entozoa are extremely abundant, only two dogs out of 100 were found to entertain this species. Fortunately the common round worm of the dog is a very harmless parasite, so far as the health of the people is concerned, and it is apparently only in exceptional instances that it proves injurious to the dog itself.

8. *Eustrongylus gigas.*—This species is probably the rarest of canine Entozoa. The only specimen which I have seen as coming from the dog is the very perfect one preserved in the Museum of the Royal Veterinary College, London. Probably not one in 5000 dogs harbours this entozoon; but since it is liable to occur in man, and has several times been noticed in the congeners of the dog, the possibility of its becoming more frequent should be considered. The Museum of the Royal College of Surgeons, London, contains some fine examples and several dissections of this parasite. I have briefly described them in the "Catalogue of Entozoa" which the Council of the College entrusted me to draw up. As Professor Leuckart has recently referred to one of the valuable specimens (No. 19)* I may observe that the œsophagus is twisted in the particular dissection there displayed. That the "spiral" form is unnatural or accidental, so to speak, is obvious; but my description certainly implied otherwise, and must therefore be corrected.

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* "Die Menschlichen Parasiten," band ii., s. 390.

9. *Bothriocephalus latus.*—Although there is some difficulty in determining the number of species of *Bothriocephalus* liable to infest the dog, it is generally agreed that this form is both human and canine, so to speak. In either case it is believed that the "host" acquires possession of the parasite by the consumption of fish. Dr. Knoch, of Petersburgh, believed he had succeeded in rearing this species in dogs by direct experiment with its embryos; but the necessity of an "intermediary bearer" has been clearly established by Leuckart. The presence of *Bothriocephali* in the dog in this country is very rare. One such cestode may be seen in the Museum of the Royal Veterinary College; and no doubt can be entertained that it belongs to this species.

10. *Bothriocephalus cordatus.*—This form is quite distinct from the above, and seems to be very abundant in the dogs of North Greenland, where it also occasionally infests the human body. In the dog it occurs in considerable numbers, and can scarcely fail to occasion the animal more or less distress; but we have no evidence to show that it gives rise to any inconvenience in the human subject, where, so far as is at present known, it either exist singly or in very small numbers. Its comparative abundance in the dog doubtless depends upon the more ready access which that animal has to the uncooked food containing the larvæ, which latter are supposed to abound in marine fish.

11. *Bothriocephalus fuscus.*—Dr. Krabbe, of Copenhagen, described a variety of pit-headed tapeworms obtained from dogs in Iceland, all of which appear to be distinct from the above species. He recognizes three separate kinds (*B. fuscus*, *B. reticulatus*, *B. dubius*), severally presenting marked features of their own; but he is not prepared to affirm that these characters have any specific value. I do not now discuss this point, but I may remark, in passing, that the preparations of *B. cordatus* sent me by Professor Leuckart, and the specimens *B. fuscus* presented to me by Dr. Krabbe, afford convincing proof of the distinctness of these two forms. Taking the *Bothriocephali* as a whole they only occur in

the ratio of five per cent. in Iceland, whilst Dr. Krabbe's investigations also show that in Denmark they are very much less frequent. In the 500 dogs examined at Copenhagen he only found one infested. It is by no means improbable that one or other of the forms will be discovered in this country.

12. *Tœnia marginata.*—The tapeworms, properly so-called, are far more numerously represented than the *Bothriocephali;* and this is one of the commonest forms. The frequency with which I have encountered it leads me to conjecture its presence in at least twenty-five or thirty per cent. of our English dogs. In Denmark it is rather less abundant, being found, according to Krabbe, in fourteen per cent., whereas in Iceland it is remarkably prevalent, occurring in no less than seventy-five out of the hundred dogs which he examined. This parasite is seldom found alone, and, being the largest species liable to infest the dog, proves a formidable guest to its canine host. Up to the present time it has not been described as occurring in man; nevertheless I have seen portions of a tapeworm, apparently referable to this species, which I was assured had come from the human subject. From the first, I expressed the strongest doubts as to its source. The dog acquires this parasite by swallowing the large cestode larvæ which are frequently attached to the viscera of the sheep. Dr. Möller, as is well-known, tried to rear this parasite in himself, by swallowing the fresh uncooked larvæ (*Cysticercus tenuicollis*), but he did not succeed; and consequently we are not at present warranted in concluding that this species can under any circumstances develope itself in man. Mr. Simonds and myself succeeded in rearing several examples of this Entozoon in the dog by direct experiment. One or two instances are on record of the occurrence of the larvæ of this species in man; and I have elsewhere pointed to affirmative evidence in yet another case. In none of these examples is there any reason to suppose that the larvæ in question did any harm; yet it would be very unadvisable to allow of steps being taken which could promote its more frequent development within the

human host. Sewage-distribution where dogs abound would aid in securing this undesirable end.

13. *Tænia cœnurus.*—This species is likewise obtained from the sheep, though by no means exclusively so, as some imperfectly informed persons seem to suppose. Its prevalence in the dog, however, is comparatively rare. I have succeeded in rearing it without any difficulty, but I do not remember to have encountered the entozoon in any dog which had not previously been made the subject of a Cœnurus-worm-feeding. I need hardly say that its larval form (*Cœnurus cerebralis*) gives rise to the "gid" in flocks; but it also proves detrimental to several other animals. Indirectly, therefore, it affects man himself; yet, in this country, the "gid-disease" is seldom sufficiently prevalent to cause serious loss to the sheep-breeder. In other countries, Hungary for example, losses on this score are said to be very considerable. In Denmark Dr. Krabbe encountered this entozoon in only one per cent. of the dogs he dissected, but in Iceland he found it in no less than eighteen per cent. Clearly the "gid" must abound in that country. It is not generally known, even by those who have some acquaintance with helminthological matters, that the larvæ of this tapeworm sometimes infest the rabbit, giving rise to a formidable disease having its seat in the muscles and soft parts of that animal. At pages 121—123 of this work, I have already explained that Mr. C. B. Rose, F.G.S., was the first to direct attention to this important fact; but his explicit statements on this head have been either carelessly overlooked, or purposely disregarded. I regret again to observe that there are persons who, whilst fairly recording the information they obtain from foreign writers, appear to be studiously careful to avoid giving credit to the labours of their own countrymen. In the curious discovery before us we have another unexpected source indicated whence the dog may obtain the adult parasite, and thus, in its turn, afflict another group of creatures with the so-called bladder-worm disease.

14. *Tænia cucumerina.*—Without doubt this is the commonest

of all the forms of canine Entozoa. I have little hesitation in saying that it is present in two out of every three dogs living in this country, excluding, of course, puppies up to three months old. Krabbe found it present in forty-eight per cent. in Copenhagen, and in fifty-seven per cent. in Iceland. It appears to be very prevalent throughout Europe, and probably is more or less so in all other countries. So far as I know, the cucumerine tapeworm is a tolerably harmless parasite; but, notwithstanding the efforts of investigators, nothing certain is understood respecting its true larval source. In the adult state it sometimes occurs in prodigious numbers, and often associated with other parasites. In one valuable animal, a pointer, which died suddenly, I found between 500 and 600 of these parasites, associated with numerous examples of three other kinds of Entozoa. In this particular instance, it appeared clear to me that Entozoa, alone, were the cause of the dog's death. If the canine tapeworm species, *which are dangerous* to human life, became as abundant in this country as the harmless *Tænia cucumerina* has been shown to be, then our mortality would be increased by many thousands annually. This will, perhaps, be made more apparent in the sequel.

15. *Tænia serrata.*—Though by no means so abundant as the preceding, this parasite is nevertheless sufficiently common, whilst it is also more injurious to the bearer. Taking one variety of dog with another, I should say that it occurs in at least five per cent. of our English dogs; but in harriers and greyhounds I have little doubt that its presence is all but invariable. At Copenhagen Dr. Krabbe only encountered this parasite once; and in Iceland it seemed altogether wanting. The practice of giving the viscera of hares and rabbits to sporting dogs (which I have myself occasionally witnessed in the field) will always ensure the prevalence of this entozoon in our dogs. On five or six separate occasions I have reared this tapeworm in dogs by administration of the larvæ (*Cysticercus pisiformis*) taken from recently killed rabbits. It is one of the most easily reared of all the canine parasites; and, if due attention

be paid to the form and size of the head and its conspicuous crown of hooks, cannot well be confounded with its allies. The older helminthologists are not trustworthy respecting the prevalence or otherwise of this species on the continent, since they regarded several distinct forms as identical. Even Dujardin was sceptical respecting the distinctive characters, severally, of *Tœnia serrata*, *T. marginata*, and *T. crassiceps* (of the fox).

16. *Tœnia litterata.*—This well-marked form is described by Dr. Krabbe under the name of *T. canis lagopodis;* but, notwithstanding the priority of Rudolphi, I prefer the subsequent and more distinctive nomenclature of Batsch, especially also because the parasite is not by any means peculiar to the Arctic fox (*Canis lagopus*). Here we know nothing of this parasite; and it may be that it does not exist in England. On the other hand, its general resemblance to *Tœnia cucumerina* may have caused it to be overlooked. It seems from Krabbe's extended researches to be altogether wanting in Denmark; but in Iceland he found it in twenty-one of the two hundred dogs which he there dissected. In the absence of any definite knowledge respecting its larval source, it may be assumed, as regards man, to rank amongst the so-called harmless species. The joints (judging from the specimens kindly sent me by Dr. Krabbe) have somewhat the appearance of those of Bothriocephali, owing to the central and ventral disposition of the reproductive organs. The orifices themselves, however, are not actually visible, though probably present in thoroughly mature segments.

17. *Tœnia echinococcus.*—I come now to speak of a parasite of the highest interest in relation to public health. Though fortunately extremely rare in the adult condition, it is nevertheless sufficiently abundant to produce occasional fatal results by means of its larvæ. What is the actual amount of human mortality thus annually caused in this country it is not easy to say; nevertheless I know it to be something considerable; and there is reason to fear, in the absence of due precautions, that it may become much

greater. The larvæ or *hydatids* are familiar to every hospital surgeon. The adult parasite has frequently been reared by foreign experimenters; but although several hydatid-feedings have been administered to dogs in England, only one such feeding has, so far as I know, been attended with positive results. In the particular instance to which I refer, the facts were originally communicated to the Royal Society by Professor Nettleship. It is quite likely, however, that I had myself previously succeeded in rearing this parasite. I say "likely," because the subject of the experiment (a small black dog) having been liberated by an ill-designing person, I lost the necessary opportunity of destroying and examining my experimental animal. It is true that I had previously, in one or two other dogs, obtained only negative results; but in those instances none of the conditions likely to ensure success were so favourable as in the case of the liberated animal. At all events, Mr. Nettleship, following up these experiments, after a precisely similar method, obtained a complete success. The freedom of only ONE animal harbouring *Tænia echinococcus* must be fraught with serious danger to the community; and yet it is to be feared that at the present time several dogs, thus infested, roam at large in this country. Certainly, I have no desire to add to their number. In Copenhagen, Dr. Krabbe encountered this parasite in *two* only out of 500 dogs; and yet the parasite is probably more abundant in Denmark than in England. In Iceland, on the other hand, where the mortality from the hydatid, or echinococcus-disease embraces one-sixth of all who die in that country, Dr. Krabbe found twenty-eight dogs out of a hundred harbouring this entozoon. Up to the present time no person has seen this parasite in any English dog which has not been previously made the subject of experiment.*

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* Dr. Krabbe, in his recent work ("Helminthologiske Undersögelser," p. 58, or "Recherches Helminthologique," p. 60,) has commented on the sense of a sensational passage, which I have correctly translated from Leuckart in a former part of this work (p. 283). He thinks I have spoken somewhat unfairly of the doings of the "quacks" in Iceland. Most of them, he says, are homœopaths; and even "those who are not,

In order to obtain an approximatively correct notion as to the amount of echinococcus-disease prevalent amongst us, I devoted some three or four weeks in the winter of 1864 to an examination of the collections of Entozoa contained in nine of the principal Pathological Museums of the metropolis. The results of this search, independently of data derived from other sources of evidence, have convinced me that hydatids are far more prevalent than is generally imagined. In these collections I found no less than 195 instances of hydatid-disease out of a total of 368 cases of helminthiasis of all kinds. It is my deliberate belief that not less than 400 deaths annually occur in England from this source. Doubtless, if one could acquire correct statistical evidence respecting the amount of fatality from all the entozootic diseases combined, the rate of mortality from parasites would be considerably larger than this figure, by itself, implies; yet it fortunately happens that comparatively few of the other kinds of Entozoa at present prevalent in England lead to fatal results. Such cases are exceptional. It is equally certain, on the other hand, that much misery and discomfort is produced by the less hurtful species. A very great deal of good might accrue from the acquisition of more extended evidence respecting the prevalence or otherwise of all the known forms of Entozoa infesting man and the domestic animals in this country. A report of this kind, drawn up somewhat after the fashion of the present communication, would, I conceive, prove highly useful. Such a report should not be a mere record of helminthic epidemics collected from foreign sources, however valuable that may be, in itself; but we ought to have a sound and scientific contribution based upon a previous practical knowledge of the Entozoa, our information being extended by personal observations made under every variety of circumstance. It is one thing to give a literary *résumé* of the progress

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treat their patients much in the same way as ordinary medical men." It simply comes to this, that, instead of *dog's excrement* forming with the aforesaid "quacks" a conspicuous or common remedy (as I had supposed from Leuckart's description), this nasty drug is now rarely administered, and by the grossly ignorant only.

of this department of science abroad, and another to record the actual position in which we stand in respect of entozootics at home. Except by exclusive and prolonged devotion to this subject no great ultimate good can be accomplished. A properly qualified person, always on the alert, could embrace many opportunities of special research which must of necessity be lost to the mere closet report-maker. In illustration of a lost opportunity, I may give an instance. In the "*Times*" of Saturday, July 14th, 1866, we read that "Among the claims presented to the Glamorganshire Court of Quarter Sessions, was a claim for poison used in killing stray dogs at Merthyr; another was from the chief inspector of the Swansea police for killing 100 dogs, at one shilling each; while the third was from a person who charged one guinea for the removal and interment of three cartloads of the dead bodies of the dogs." I have no doubt whatever as to the wisdom of destroying these animals; but I have to add that an examination of the bodies of these animals by a skilled helminthologist would have been particularly instructive and practically useful if conducted in relation to the great subject of Entozootics.

18. *Pentastoma tœnioides.*—This parasite resides in the nasal cavity and frontal sinuses of the dog, but it is comparatively rare in England. In the young state, and under a different name (*P. denticulatum*), it is frequently seen in the human body on the Continent. Its mode of introduction into the latter "host" has not been ascertained with certainty; yet there can be very little doubt that the sneezing of an infested dog in the face of any person would readily transfer the eggs and embryos of the parasite from one "host" to the other. In like manner, and by the same means, the ova may be cast over and become attached to food, and then be subsequently conveyed to the human stomach. Fortunately its presence in man appears to be unattended with danger; yet any considerable number of these parasites could scarcely fail to produce more or less inconvenience. In Germany it seems to be rather abundant; for Frerichs (no mean authority) states that it

is "far more common in the human liver than the echinococcus." In confirmation of this statement, it has been shown to be present in from five to fifteen per cent. of *post mortem* examinations conducted in different German cities. I have myself frequently encountered this parasite in the juvenile state in animals, but not in the human body. The Pentastomes recently described by Dr. Aitken, from the human liver, belong to another and more formidable species. Strictly speaking, these creatures are not true Entozoa, although their habits often cause them to be classed as such. Their mode of introduction into the nostrils of the dog is readily accounted for, since the larvæ are constantly present in the flesh of herbivorous mammals, and must frequently, during the act of feeding, be brought in immediate contact with the dog's nose.

19. *Cysticercus* (*telæ*) *cellulosæ*.—Two or three authors (Gurlt, Chabert, and Hartwig) have stated that the common measle of the pork-tapeworm is liable to occur in the dog; and, since we know that it is occasionally found in man, there is no good reason for doubting the correctness of their conclusions. It has been found attached to the membranes of the brain, in the muscles, and in the cavity of the abdomen. If the dog were a thoroughly suitable "host," this larva would, in all likelihood, be much more common in the canine bearer than it is at present supposed to be. The possibility of its occurrence, and the probability of its having been frequently overlooked, should both be considered in reference to future investigations in this direction.

20. *Filaria trispinulosa.*—This little parasite, once found by Gescheidt in the eye of a dog, is probably only a sexually immature form of *Ascaris*. The specimen, however, was one-third of an inch in length, and recorded as a female. It does not appear to have since been met with.

21. *Filaria sanguinis.*—Under this title I have a few more words to say respecting the so-called hæmatozoa of MM. Grube and Delafond. These investigators, some years back, examined

480 dogs, and in nearly five per cent. they found Filariæ in the blood. The parasites were extremely minute, their diameter being less than that of the dog's blood-corpuscle! There can be no doubt that they were larvæ of some known, or unknown, species of nematode. I have already hinted that these hæmatozoa might be the brood of *Spiroptera sanguinolenta*; yet in only one instance did these authors find sexually mature nematodes (of comparatively large size) in the heart. In this case they obtained six specimens, "of which four were females and two males; the parasites being lodged in a large clot of blood occupying the right ventricle." They measured from one-half to three-fourths of an inch in length. MM. Grube and Delafond believed they had encountered a new species, and accordingly gave it the combined name of *Filaria papillosa hœmatica canis domestici.* In most of the dogs the entire circulatory system does not appear to have been examined; therefore it is quite possible that adult worms may have been present in more instances than the one specified—perhaps in several. If such had been proved to be the case, it might have been fair to have inferred a genetic relation between the microscopic hæmatozoa on the one hand and the worms in the heart on the other. As the matter now stands, we are in doubt as to the true adult representative of these minute *Filariœ.* With the verminiferous blood MM. Grube and Delafond performed a variety of curious experiments, but they did not, so far as I am aware, employ any worm-feedings. They satisfied themselves that the hæmatozoa could only live, as such, in the blood itself, and they estimated that the verminous dogs severally entertained from 11,000 to about 224,000 of these larvæ. In no case, however, did the infested animals appear to have suffered any inconvenience.

Conclusion.—I have thus, in a condensed form, brought together a large number of facts having reference to the frequency of occurrence and to the great variety of Entozoa liable to infest the dog; this record embracing all the more essential details I have previously made public. The way in which I have treated the subject is somewhat novel, my object being to open up a new field of inquiry, bearing more or less closely on questions of public health. The full importance of helminthology in relation to entozootics can only be understood by expositions of this kind, based upon investigations extending over a long period of time. To do justice to the subject, one must not only be acquainted with the commoner forms of Entozoa, but also, to some extent, with the rarer. The experimental method enables us to determine the origin and course of development of many forms, and helps us to discriminate between the harmless and baneful species. Systematic zoology, apart from its own abstractedly scientific value, is of great assistance in aiding our arrangement of the facts in a methodical and easily understood manner. A consideration of all the known data relating to any one particular entozoon often permits us to state precisely to what extent the species is injurious to the human race, and whether or no it is a hurtful parasite during its larval stages of development in the particular intermediary bearer which it happens to infest. We are also frequently in a position to point out, on the one hand, what circumstances are sure to increase, or, on the other, to decrease, the prevalence of any particular species. We can even go further than that, and show how certain parasitic forms may be entirely eradicated. At all events, we have it in our power, both to diminish the number of human sufferers from entozootics, and to check, if not entirely to prevent, the invasion of these endemics. Substantial results of this kind being patent to all intelligent people, we can afford to disregard the policy of the ignorant who deride our labours.

VIII.

ON THE ENTOZOA OF GAME BIRDS AND ON THOSE OF THE COMMON FOWL.

The year 1867 will long by remembered by sportsmen, on account of the scarcity of grouse caused by an epidemic exclusively effecting these birds. Not that there was any essential difference between the phenomena of the disorder then presented, as compared with the features of the disease recorded from previous experiences of this sort; but, the epidemic being somewhat more virulent than usual gave rise to the notion that we had here to deal with a new malady. As some people were strongly impressed with the belief that the epidemic was due to the prevalence of Entozoa in grouse, I undertook to draw up a brief statement showing the present state of our knowledge respecting the internal parasites of game birds generally and of the grouse in particular. My observations on this head were originally communicated to the meeting of the British Association, held at Dundee in the above-mentioned year; but, beyond certain imperfect notices which appeared in the public journals at the time, no particular record of them has been published. In the persuasion that the following summary of facts may serve as a useful point of departure for future inquiries, I do not hesitate to give them a more formal expression.

As I have just said, the idea of the "grouse-disease" being due to the prevalence of cestoid Entozoa was manifestly erroneous. Not only were the symptoms exhibited by the infested birds entirely at variance with such a notion, but the *post mortem* appearances distinctly proved that the disorder was due to other causes. The mere fact that in several or even in many instances tapeworms were found in the intestines of the birds afforded no positive proof of injurious influence from this source, especially since there was no evidence showing that the parasites were more abundant than usual. It is not easy for people unacquainted with the phenomena of parasitism, and with the mode of distribution of the Entozoa, to shake off the very prevalent notion that tapeworms are generated only in diseased or unhealthy animals. This old and erroneous idea has been handed down from age to age, and it will probably prevail amongst us for many years to come. It is not my present purpose to offer any opinion respecting the actual cause of the grouse-disease; but I am prepared, nevertheless, to show that it has no necessary connection either with the presence or absence of Entozoa. It is one thing to admit the occasional destruction of game birds from the prevalence of tapeworms, and quite another to suppose that their presence could give rise to the singular morbid appearances which were found in the diseased grouse of the year 1867. Amongst all the various birds and mammals from which I have removed Entozoa, *post mortem*, I never remember to have found the alimentary canal inflamed, and certainly there was no such disorganisation of the liver and lungs as obtained in the case of birds dying of the "grouse disorder." No amount of tapeworms could ever give rise to grangrene and pyæmia of these organs; and even in cases where the parasites are sufficiently numerous to prove fatal to the "bearer," death never supervenes in the manner shown to have taken place in the grouse affection. As a rule, tapeworms and other adult forms of Entozoa in animals are liable to produce emaciation, gradually destroying life when present in any considerable number; but in the "new disease" the birds were frequently quite plump at the time of their death, and the numbers of Entozoa present were never very remarkable. In the striking instance (recorded by Mr. J. K. Lord in *Land and Water*) in which the lungs, liver, and heart of a grouse, shot on the wing, were excessively diseased, no tapeworms existed; and, in short, without going into further details, I dismiss the notion of any entozootic influence as producing that remarkable epidemic. The subject of Entozoa in birds, apart from this epidemiological question, is not without interest in itself; and, although it cannot be said that our knowledge of avian Entozoa is on a par with that we possess of the mammalian parasites, yet a mere glance at the following list will show that we are not entirely ignorant of the many varieties liable to infest our game birds. Their abundance in the common fowl will doubtless surprise most persons; but they may take comfort in the assurance I can offer as to the perfect harmlessness, so far as man is concerned, of any of the parasitic species. In other words, it may be safely affirmed that the common fowl and all kinds of game, however imperfectly cooked, may be eaten by man with entire impunity:—

List of Entozoa infesting game birds and the common fowl.	Pheasant.	Capercaillie.	Black Grouse.	Red Grouse.	Grey Partridge.	Red Partridge.	Quail.	Fowl.
Monostoma verrucosum, Zeder . .								*
Distoma oxycephalum, Rudolphi .								*
Distoma ovatum, Rudolphi . .								*
Distoma lineare, Zeder . . .								*
Distoma dilatatum, Miram. . .								*
Distoma fuscatum, Rudolphi . .							*	
Ascaris vesicularis, Froelich . .	*	*		*	*		*	*
Ascaris gibbosa, Rudolphi . . .								*
Ascaris inflexa, Rudolphi . . .		*						*
Ascaris compar, Schrank . . .			*	*	*		*	
Spiroptera hamulosa, Diesing . .								*
Spiroptera helicina, Molin . .						*		
Dispharagus nasutus, Dujardin . .								*
Dispharagus spiralis, Molin . .								*
Sclerostoma syngamus, Diesing .	*				*			*
Trichosoma longicolle, Rudolphi .	*	*	*		*			
Tœnia malleus, Goeze								*
Tœnia microps, Diesing . . .		*	*					
Tœnia calva, Baird				*				
Tœnia linea, Goeze				*	*		*	
Tœnia infundibuliformis, Goeze .	*							*

This list comprises twenty-one forms; but I am by no means prepared to say that they are all really distinct species. In one or two cases the so-called species are probably only varieties. Provisionally regarding the list as correct, we have here to deal with three separate groups of Entozoa—namely, flukes, round worms, and tapeworms. The series of flukes consists of six species, five of which are recorded as infesting the fowl only, the sixth being confined to the quail. I may mention that the ovate fluke (*Distoma ovatum*), though not apparently prevalent in game, is common to many other birds than the fowl. It has once or twice been found in the eggs of the fowl. The round-worm series comprises ten species. Of these, seven infest the fowl. The most important is that form (*Sclerostoma*) which gives rise to the "gapes." As I have already written on this subject at considerable length in the present work (pp. 84—91) I will only add that no new facts of any importance have come to light since the time of publication of my previous papers on this subject in the "Proceedings of the Linnean Society" and in the *Field* for June 22, 1861. The round worm of the cæcum (*Ascaris vesicularis*) probably infests all game birds; for, in addition to the habitations here recorded in the fowl, pheasant, capercaillie, grouse, partridge, and quail, I have found it infesting the cheer-pheasant, the ring-necked pheasant, and the black-backed kaleege (*Euplocoma*). The curved round worm (*Ascaris inflexa*), like the ovate fluke, has been discovered within the white of the egg of the common fowl. Many birds are liable to have a species of nematode (*Spiroptera helicina*) take up its residence in the foot, causing tumours in the neighbourhood of the joints; but, so far as I am aware, the parasite has not been observed in the game birds of England, Scotland, or Ireland. With the above exceptions, it does not appear that any of the remaining forms of round-worm are capable of giving rise to severe disease in these birds. As regards tapeworms the case is somewhat different; yet, even here, the health of the avian "bearer" only suffers when, as occasionally happens, the parasites exist in prodigious numbers. I have been repeatedly asked to give the scientific name of the particular species which infests the grouse. In the foregoing list it is entered as the *Tœnia linea.* I have little doubt that this is the species, although no one in this country has hitherto recognized it as such. Specimens of grouse tapeworm, from the collection of the late Dr. Johnson, of Berwick, have been described in the "Catalogue of Entozoa contained in the British Museum" as referable to a distinct species (*Tœnia calva*). In the list at the previous page I have recorded this latter form as distinct; but I am of opinion, judging from Dr. Baird's description, that it is identical with the variety long ago known to infest the partridge and the quail. To show how prevalent this parasite is in the latter bird, I may mention that Rudolphi found it in six quails out of seven. In the fully developed state, its length varies from four to twelve inches. In specimens examined in the year 1867, I found the diameter of the head only $\frac{1}{80}$th of an inch, that of the neck $\frac{1}{250}$th, that of the proboscis (and its circle of hooks) $\frac{1}{280}$th, that of the primitive egg-capsules $\frac{1}{200}$th, whilst that of the true egg itself was only about the $\frac{1}{1000}$th of an inch. All authors have described the proboscis as unarmed; but I demonstrated the existence of hooks which, estimated roughly (for I did not succeed in isolating them), appeared to be scarcely the $\frac{1}{1400}$th of an inch in their longest diameter. Nothing is actually known respecting the cysticercal stages of development of this tapeworm; but it is quite clear that the embryos are remarkably minute, and thus well fitted to take up their temporary residence within the bodies of small insects or their larvæ. It is highly probable that these are the sources whence the larval cestodes are obtained by the birds in whose intestines they are subsequently found in their final stages of growth. The subject of bird-tapeworms is one of very great extent; and, with the exception of Dr. Krabbe, of Copenhagen, I know of no one specially engaged in working at this interesting group. From time to time I have encountered a variety of cestoid Entozoa in birds, but hitherto I have been able to do little more than record their occurrence. So far as my observations have extended, the forms are exceedingly numerous; but the species cannot be satisfactorily defined or identified without the aid of a prolonged and careful microscopic search. The list offered in these pages is, doubtless, imperfect; yet, as it is the first of the kind put together in this particular form, I am inclined to believe that it will be found useful, if only as a table of reference.

IX.

OBSERVATIONS ON THE DISTOMA CLAVATUM OF THE SWORD-FISH AND ON THE SO-CALLED DISTOMA ELEPHANTIS OF THE INDIAN ELEPHANT.

The following remarks comprise the substance of two papers which I separately communicated, one to the Linnean Society, and the other to the Meeting of the British Association, held at Norwich in 1868. The brief account of the elephant's fluke has since appeared in the "Microscopical Journal," jointly edited by Dr. Lankester, F.R.S., and his son, Mr. E. Ray Lankester.

During my stay at Lynn, Norfolk, in August, 1865, a fine example of the common sword-fish *(Xiphias gladius)* was cast ashore in the estuary. Although quite dead when discovered, the creature was in a tolerably fresh condition; and when subsequently dissected by Dr. John Lowe (who has for years past devoted considerable attention to the zoology of the Norfolk estuary) and myself, some of its internal parasites were still alive. Respecting this interesting fish, I will only add, by way of proof as to its full growth, that it measured exactly ten feet and two inches from the tip of the snout to the end of the upper division of the tail.

Five different species of Entozoa were encountered in the flesh and intestinal canal of this "bearer"—namely, *Distoma clavatum*, *Ascaris incurva*, *Bothriocephalus plicatus*, *Tetrarhynchus attenuatus*, and a form of *Scolex* referable to a second species of the last-named genus. On the first-named of these parasites I offer the following observations,—not, indeed, with the view of seeking to establish the existence of several new species by splitting up an old one, but rather for the purpose of showing that the *Distoma clavatum* may be viewed as representing a variety of forms hitherto regarded as separate species by helminthological writers.

Distoma clavatum.—Five examples of the trematode, which I believe to be referable to this species, were found in the stomach of the fish. They severally varied in length from four lines to two inches; being dead, and apparently only very slightly, if at all, decomposed. They differed somewhat in shape; but all had the so-called head and neck directed backwards. In one example the anterior slender moiety formed a right angle with the body proper, the margin of the ventral acetabulum, viewed from before, being, as it were, placed on a level with the oral sucker. Below the ventral sucker, the two largest specimens were distended with eggs and black pigmentary matter, all of them showing, internally, a dark spot near the centre of the neck. All of them likewise exhibited more or less well-marked transverse rugæ, extending from the root of the ventral sucker to the lower end of the body. The last ring thus formed surrounded a distinct caudal orifice, representing the outlet of a largely developed contractile vesicle. The eggs presented an average longitudinal diameter of $\frac{1}{800}''$. Some other points bearing upon the question of specific difference will be incidentally mentioned below.

When occupied, a few years since, in revising the collection of Entozoa contained in the Museum of the Royal College of Surgeons, London, I encountered a variety of parasites without any labels attached, or any mark capable of guiding one as to the source of the specimens. Amongst these were several flukes, which, though differing from each other in respect of size and shape, appeared to be identical species. One of these specimens I afterwards found to be the individual example of *Distoma clavatum* long ago described and figured by Professor Owen in the Zoological Society's Transactions. Several of the others I have since (by comparing them with specimens deposited in the British Museum) clearly made out to be part of a series contributed by Mr. George Bennett; but the College Museum-stores contained yet a third group of specimens, whose history had hitherto evaded all my endeavours to unravel it. The large fluke described by Professor Owen was formerly in the collection of the Rev. Lansdowne Guilding; but we do not know from what fish it was obtained. In Dr. Baird's catalogue, the specimens presented by Mr. Bennett are stated to have come from the stomach of a Bonito; and it is not improbable that Mr. Guilding's specimens, as well as many others whose history is wanting, may be referred to the same "host." Be that as it may, the specimens in question not only differ very markedly among themselves, but also, in some respects, from many other forms referable to the same species. I here allude to the various specimens described by systematic helminthologists, some under one title and some under another. In fact, a species-splitter can point to five or six tolerably distinct forms, which, in my view, ought to be regarded as specifically identical. To prove this, however, it is necessary to investigate the matter with some care, and to pass in review all the more important notices which have from time to time appeared.

In the year 1730, M. Garsin, a surgeon in the employ of the Dutch East-Indian Company, and Corresponding Member of the French Academy of Sciences, first described this worm, under the generic title of *Hirudinella*. He says:—"Cet insecte tiré de l'estomac de la Bonite ne vécut qu'environ deux heures. Exposé à l'air il étoit languissant, et reprenoit de la vivacité dans de l'eau de mer. Il diminua sensiblement de volume pendant qu'il vivoit encore."* M. Garsin's brief description is accompanied by three figures, two of them giving a plan of the possible movements of the head and neck on the one hand, and of the body on the other, the ventral sucker being the fixed point. His specimens do not appear to have exceeded one inch and a half in length.

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* Histoire de l'Acad. des Sciences à Paris, 1730, p. 44.

In 1774, Pallas described a trematode under the generic and specific name of *Fasciola ventricosa.* It measured two inches in length; but we are left in doubt as to whether it was actually obtained from a fish. All that he says regarding its source is as follows:—"Ex Amboyna missum fuit singulare hoc molluscum, quod ad aliud quam Fasciolarum genus referre non potui, in quo quasi gigas erit."* He remarks upon its pale white colour, and notices particularly the soft elastic body proper, which when wounded gave out a dark matter resembling soot. This material, when examined with the microscope, appeared perfectly fresh; it was certainly not the result of decomposition. Pallas also gives many other details respecting the structure of the parasite, accompanied by a figure.

In 1790, Menzies likewise described and figured a fluke about two inches long, which, though differing remarkably from the foregoing in respect of shape, is nevertheless identical. His account of the parasite is recorded in the first volume of the Linnean Society's Transactions, and he calls it *Fasciola clavata:*—"It is of whitish colour, somewhat pellucid, discharging at its mouth a black-coloured fluid which can easily be perceived through its body. I have often found it," he adds, "in the maws of the Bonito, between the tropics in the Pacific Ocean."† Notwithstanding the similarity of description, Menzies does not appear to have recognized the identity of his worm with that described by Pallas. Professor Owen, however, subsequently established this identity, and referred to this species as the *Fasciola clavata* seu *ventricosa.*‡ On the other hand, the British Museum Catalogue represents Pallas's worm as specifically distinct from that of Menzies, but as identical with the specimen described by Professor Owen from Mr. Guilding's collection.

In 1802, Bosc described and figured a trematode under the title of *Fasciola fusca.* This he obtained from the intestines of a Dorado. In form it differs considerably from any of the foregoing species, with all of which, however, it is probably identical. Bosc's description runs as follows :—" Brune, la partie postérieure très-renflée, presque ovale ; la partie antérieure mince, cylindrique, inégale, avec deux petits tentacules en dessous. Le suçoir de l'anus très grand."* Bosc recognized the identity of his worm with the *Distoma Coryphenæ* of Rudolphi ; and systematists generally have adopted his synonymy. In the British Museum Catalogue, the *Fasciola fusca* and *F. ventricosa* of Pallas are regarded as one and the same species. If two small appendages did really exist below the oral sucker, then Bosc's worm is certainly a distinct species. I have never seen anything resembling this amongst the trematode parasites—though the exserted penis might very well be mistaken for one such process. Helminthologists, generally, appear to have doubted the existence of such developments.

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* Spicilegia Zoologica, Fascic. x. (1774), p. 18.

† Trans. Linn. Soc., vol. i. (1790), pp. 187, 188.

‡ Trans. Zool. Soc., vol. i. (1835), p. 382.

In 1827, Nardo obtained two very large flukes from the stomach of a fish captured in the Gulf of Venice during the month of September. He calls the fish *Prostostegus prototypus,* which appears to be the same as the *Luvarus imperialis* of Rafinesque. One of the parasites being no less than five inches in length, and nearly half an inch in breadth, he appropriately named the species *Distoma gigas,* believing, naturally enough, that he had to deal with a new species. His description is as follows :—" Distoma teres, rubrum, retractile ; poro ventrali minimo cujus apertura magna, rotunda, ciliata ; poro antico terminali, parvo ; collo brevi, retrorsum divergente, extensili, apice angusto, basi lato ; cauda longa, postice incrassata et in apice obtuso osculo donata."† Here, again, a character is introduced, the nature of which it is extremely difficult to understand. I allude to the alleged ciliated condition of the ventral sucker, an appearance perhaps due to a wrinkled state of the lip. Apart from this, I see no reason for supposing this parasite to be distinct from the *Distoma clavatum* procured by Mr. Guilding, or the *Fasciola ventricosa* described by Pallas. The intestines of the fish in question harboured another trematode parasite, to which Nardo applied the title *D. Rayneri-anum.* This appears to be a distinct species; but its size is not stated. Unfortunately, Nardo gives no figure of his *Distoma gigas.* It is the longest fluke at present known.

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* Hist. Nat. des Vers, vol. i. (1802), p. 271.

† Isis, for 1833, p. 523 ; from Heisinger's "Zeitschrift," 1827, p. 68.

In the year 1835, Professor Owen communicated to the Zoological Society the anatomical memoir to which I have already made reference. In his paper he ably discusses several questions relating to the structure of *Distoma clavatum,* and throws considerable light upon the organization of this species. He quotes the previous writings of Pallas, Rudolphi, and Menzies, and establishes the identity of *Fasciola ventricosa* and *F. clavata.* Although some particulars are wanting respecting the precise mode of termination of the digestive tubes, I think that there can be no doubt as to the propriety of retaining this species amongst the true Distomes. I believe that the large "lateral cavities" described by Professor Owen are neither more nor less than the somewhat unusually distended alimentary cæca. In this particular, every helminthologist is familiar with the varieties presented by different species of Trematoda. At all events, there is here no good ground for retaining the generic name *Fasciola;* and still less are we called upon to recognize any of the forms under the title of *Hirudinella,* although Garsin first described the species under this generic title.

In 1845, Dujardin placed the worm with the true Distomes, yet, at the same time expressed grave doubts as to whether it were, in any sense, a fluke. "Ce ver," he remarks, "n'est certainement pas un distome ni même un trématode. Si sa forme extérieure et ses deux oscules lui donnent quelque ressemblance avec les distomes, sa structure musculeuse le rapproche davantage des Gordius, et son tégument ressemble à celui des siponcles."

M. Dujardin carefully examined the specimens preserved in the Paris Museum; and, with regard to one particular example, described as "Fasciola, trouvé dans la mer de Nice," he says, it presents "une certaine analogie avec le prétendu *Distoma clavatum*." Manifestly Dujardin himself was somewhat puzzled by the resemblances in question. He does not appear to have had any opportunity of examining fresh specimens; yet he mentions the species as tolerably common in the Bonito, being also occasionally present in the Tunny. At all events, it would appear, by evidence derived from various sources, that the rightly so-called *Distoma clavatum* is not unfrequently taken from the ocean quite independent of its piscine "bearers."

In reviewing the foregoing notices, it is, of course, open to any naturalist to doubt if these parasites, one and all, can be said to refer to the same species; yet, notwithstanding the many divergences of statement, if any one will take the trouble to examine all the specimens preserved in this country I think he will arrive at the conviction which I expressed at the outset of my remarks. It is a comparatively easy task to name afresh every entozoon which happens to come into one's possession; but to ascertain how often it has previously been described may involve a good deal of labour. As an illustration of the truth of this observation, I subjoin a list of the synonyms which I believe to be referable to the species under consideration:—*Distoma clavatum*, Rudolphi =*D. Coryphænæ*, Rud.=*D. gigas*, Nardo=*Fasciola clavata*, Menzies=*F. Coryphænæ*, Bosc=*F. Coryph. Hippuridis* and *F. Scombri Pelamidis*, Tilesius=*F. fusca*, Bosc=*Hirudinella marina*, Garsin =*H. clavata*, Baird.

Probably we may here also include Rudolphi's *Distoma tornatum;* but I have never seen the caudal extremity of *D. clavatum* projected to the extent described by Dujardin as occurring in *D. tornatum* though I think it quite capable of becoming so. Diesing, in my view, gave this accidental invaginating process too much prominence as a specific character when he wrote in regard to

D. tornatum, "Cauda longissima, gracilescente, moniliformi," overlooking the circumstance that the tail is normally truncated posteriorly. Whether the correctness of my opinions respecting the synonymy of *D. clavatum* be admitted or not, I am confident, as regards certain other reputedly distinct forms of this genus and its allies, that they have had a common origin.

Distoma Elephantis.—On the 24th of June, 1868, I received a small bottle containing two flukes. It was accompanied by a note from Dr. Baird, F.R.S., stating that the specimens had been transmitted to him from India by Dr. Hugh Cleghorn. On the phial itself was a brief notice to the following effect:—"Distoma taken from liver of elephant at Rangoon, forwarded for classification to Professor Cobbold by Veterinary Surgeon J. Thacker, Madras Army." This is all I know of the history of these two Entozoa. On naked-eye inspection it was clear to me that they were identical in character with a larger series of specimens exhibited by Professor Huxley during the delivery of a course of lectures at the Royal College of Surgeons in the spring of the same year. Having communicated to Prof. Huxley the facts as above stated, I received permission to make use of his set of specimens, originally fifteen in number, for the purposes of comparison and description. This series was placed in the hands of Mr. Flower, F.R.S., last February, and, under his direction, six of the individuals were subsequently selected and mounted, with the view to their being added to the valuable collection of Entozoa contained in the Hunterian Museum.

The first thing to be determined was as to whether or not these flukes were new to science. In this relation, therefore, I have to remark that so far back as the year 1847, Dr. Jackson, in his "Descriptive Catalogue of the Anatomical Museum of the Boston Society for Medical Improvement," incidentally mentions the occurrence of flukes in the Indian elephant. Though several examples were removed from the biliary ducts and duodenum, along with many specimens of *Ascaris lonchoptera*, it does not appear that any of them have ever been properly described. In all likelihood (if, happily, the flukes are still preserved in the Boston Museum) it will be found that they specifically correspond with those now in our possession. I may add that the late C. M. Diesing, in the appendix to his well-known "Systema Helminthum," had already, in 1850, noticed Jackson's statement (vol. ii., p. 560), and also subsequently in his more recent "Revision der Myzelminthen" (s. 50). In the last-named work, which bears the date of 1858, Diesing still regarded the entozoon as a doubtfully distinct form, allowing it, however, to appear under the title of *Distomum elephantis*. In my synopsis of the Distomidæ, communicated to the Linnean Society in 1859, I admitted it, conjecturally, as a good species ("Proceed." for 1860, Zool. Div., vol. v., p. 9). That determination has since proved correct, for it now turns out that this elephant-fluke (judging from those that were placed in my hands) is not only a distinct species, but that it differs also generically from the Distomes properly so-called. In point of fact, it is a sort of transition-type between the genera Fasciola and Campula (Fig. 3). This last-named genus I established in 1857 for a form which I found in the liver-ducts of the common porpoise; but as the species under consideration comes rather more closely to

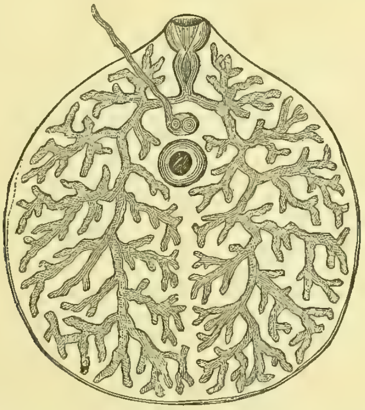

FIG. 3.—Fluke (*Fasciola Jacksoni*) from the Indian Elephant, showing the arrangement of the digestive canals, the suckers, reproductive vesicle, and incompletely protruded intromittent organ. (× 6 diam.)—Original.

the genus Fasciola than to Campula, I shall not seek to complicate matters by adding another generic type. Anyhow, the nomenclature must be altered; consequently I herewith correctly name and describe the species as follows:—

Fasciola Jacksoni, Cobbold.—Body armed throughout with minute spines, orbicular, usually folded at either end towards the ventral aspect, thus presenting a concavo-convex form; oral sucker terminal, with reproductive papilla about midway between it and the ventral acetabulum; intromittent organ ¼″ in length; digestive apparatus with two main zigzag-shaped canals, giving off alternating branches at the angles thus formed, the ultimate cæcal ramifications together occupying the whole extent of the body; length, when unrolled, from ½″ to ⅝″; breadth, ⅓″ to ½″.

In all the specimens examined by me the alimentary tubes were occupied with inspissated bile; so completely so, as to supersede the necessity of any attempts at artificial injection. I ought also to add that the cæca and branches of the alimentary system are more numerous than actually represented in the accompanying illustration. Mounted examples of this entozoon may now be seen in the Museum of the Royal College of Surgeons. They have been added to the Hunterian collection since the publication of the catalogue of Entozoa. Nos. 8 & 9 in that list are examples of the above described *Distoma clavatum*, "probably obtained from a Bonito."

X.

ON THE QUESTION OF ORGANIC INDIVIDUALITY, ENTOZOOLOGICALLY CONSIDERED.

The following views were originally expressed in very similar terms in a paper which I communicated to the Linnean Society:—

When Professors Carpenter and Huxley promulgated their original and philosophic views respecting the question of animal individuality, they virtually established a general proposition regarding the constitution of the "zoological individual," which forms an admirable stand-point by whose aid I think it possible to interpret the significance and relations of that complicated series of life-phenomena in the Entozoa, hitherto so much misunderstood and undervalued.

The general proposition here referred to was formally embodied in the announcement that the "zoological individual" comprises the sum-total of the phenomena displayed by all the products of a single ovum, or, to employ Professor Huxley's own words, "the *individual* animal is the sum of the phenomena presented by a single life."

Many physiologists have asserted that the human frame, during its life-period, is represented by several epochs, each of which is, for the most part, distinctive and separable in so far as actual matter or tissue is concerned, but inseparable and almost indistinctive as regards mere appearances, whether external or internal. In other words, during man's growth we have a definite succession of life-phases; these being, in my view, analogous to, if not in any sense homologically identical with, the distinctive and peculiar temporary forms of life so notably characteristic of certain of the lower animal types, particularly of the Entozoa.

Taking, as it were, a bird's-eye view of the whole zoological series, these temporary life-phases display every degree of distinctiveness from the almost imperceptible up to the separable, free, individual-like form for the designation of which Professor Huxley has felicitously proposed the term "zoöid." All these phases are now known to be phenomena of growth, metamorphosis, and gemmation, there being no such thing as "alternate generation" in the more legitimate sense of this phrase.*

Applying these principles to the interpretation of the phenomena of entozootic life, some very curious results appear to be attainable when we come to deal with the more complicated forms. Starting, however, with a species where the individual is represented by simple, non-metamorphosed life-phases, we necessarily encounter the almost indistinctive conditions of ordinary growth. Thus I select, in the first instance the *Trichina spiralis* whose life-phenomena (according to the synoptical method initiated in this work, at p. 115) may be tabulated as follows:—

Zoological individual (*Trichina spiralis*).
a. Ovum in all stages.
b. Intra-uterine embryo.
c. Free embryo or migrating larva.
d. Resting or sexually immature larva (finally encysted).
e. Free, sexually mature, intestinal *Trichina*.

Now, although the various larval stages above indicated bear a general resemblance to the adult *Trichina*, we have, even here, some faint traces of "epochs" which, were they only rather more strongly pronounced, would enable us to draw lines of demarcation. In some instances the life-epoch may be homologically identical with a temporary bud, but it may also comprise a multitude of

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* Probably, in the case of Rhabditis we have a true alternation of generation, or, to say the least, a true sexual dimorphism in animals (see Leuckart in "Nachrichten von der Königl. Gesellsch. der Wissensch. zu Göttingen," No. 8, April 19, 1865, s. 227).

gemmæ. Each such successive life-epoch, whether distinctive or indistinctive, separable or inseparable, I propose to call a *biotome;* and when two or more such life-divisions are recognizable, I propose to call them "secondary" or "tertiary" biotomes, as the case may be. I would observe that the term "biotome" is not designed to supersede the term "zoöid," but rather to limit the latter to an individualised, free, constituent portion of the "biotome." The propriety of this arrangement will, I think, appear in the sequel. Let us, therefore, in the next place, glance at the life-phases of one of the cestodes. Those of *Tænia serrata* may be tabulated thus:—

ZOOLOGICAL INDIVIDUAL (*Tænia serrata*).

a. Ovum in all stages.	Primary "biotome."
b. Six-hooked embryo, boring larva, or proscolex.	
c. Resting larva, scolex, or *Cysticercus pisiformis.*	
d. Sexually immature tapeworm in all stages.	Secondary "biotome."
e. Mature tapeworm-colony, strobile, or *Tænia.*	
f. Segment, free-joint, or *proglottis* (zoöid). .	

According to Professor Huxley's views, in the above "individual" the stages *a, b, c, d,* would collectively represent the first life-phase or "protozoöid," whilst the final phase, *f,* would be the "deuterozoöid." I have, indeed, with Professor Huxley's approval, so represented them in another part of this treatise (p. 222); but, recently, I have not been able to satisfy myself that the nomenclature in question meets all the requirements of the case. In my view, the six-hooked embryo is as much an individualised form as the *Cysticercus*-stage, whilst the latter is as much a life-phase as the *proglottis* itself. Why, therefore, may we not here recognize three zoöids (proto-deutero-trito-zoöids), instead of two only, after the manner suggested by Professor Huxley? If this view be accepted, our *Tænia serrata,* in its full zoological individuality, would be represented by two biotomes, the primary one comprising two individualised phases (the proscolex and scolex, or protozoöid and deuterozoöid), and the secondary one comprising a practically indefinite number of individualised forms or tritozoöids. In the one case the independent life-phases are the result of metamorphosis, but in the other they are the product of gemmation. Let us next see how the matter stands in regard to one of the Trematodes, say, for example, the common liver-fluke (*Fasciola hepatica*), which may be tabulated as follows :—

ZOOLOGICAL INDIVIDUAL (*Fasciola hepatica*).	
a. Ovum in all stages.	First "biotome."
b. Ciliated free-swimming embryo. . . .	
c. Non-ciliated larva (nurse, germ-sac, sporocyst, *redia*).	Second "biotome."
d. Active, migrating, tailed larva (*cercaria*). .	Third "biotome."
e. Encysted, resting larva (*pupa*). . . .	
f. Sexually mature fluke (*fasciola*). . .	

This is probably a fair representation of the ordinary fluke individual, in which species, however, the entire life-phases have not as yet been thoroughly identified. It is quite certain that the life-phases are never less numerous or complicated than is here indicated; whilst Pagenstecher's researches tend to prove that, under certain climatal conditions, the number of larval forms may vary considerably. In other words, the fluke individual does not comprise any definite number of "zoöids," although the kinds of zoöids are limited. In the present case I recognize three "biotomes." The first includes only one temporary, independent life-phase; this is the ciliated animalcule, which, in my view, possesses sufficient individualised life to entitle it to be recognized as a "protozoöid." The second "biotome" may in some cases comprise only a solitary, simple sporocyst or germ-sac (deuterozoöid); but an almost indefinite multiplication of new and independent germ-sacs, as well as other more highly organized "nurse-formations," may also be developed from the primary sporocyst (secondary and tertiary "deuterozoöids"). This reminds us of the practically indefinite number of zoöids (proglottides) which the second "biotome" of the Cestode gives rise to; but here there is analogy, and not homology. The third "biotome" embraces a large but variable number of "tritozoöids" *(cercariæ)*, an equal number (whatever that may be) of "tetartozoöids" *(pupæ)*, and, therefore also, a similar number of "pemptozoöids" (flukes).

Whether the views here promulgated be accepted or not, I have, I trust, made it sufficiently clear that the fluke-individual may comprise, in its life-cycle, a great and varying number of life-phases, each of which may or may not possess equivalent (and, necessarily, very limited) zoological value. The variability of the character of these life-phases is shown by the sporocysts (deuterozoöids), which are not only unequal to one another in bulk, but also in organization, the higher forms (rediæ) developing a rudimentary digestive apparatus. Apparently the *redia* is not, in all cases, an essential feature of Trematode larval life. Putting together the whole possible and independent life-phases, and placing their numerical development within the lowest limits, our ordinary fluke-individual would, I reckon, comprise about 370 "zoöid" formations, those of the second "biotome" being produced by the well-known process of internal gemmation, whilst those of the third "biotome" are the result of a simple yet prolonged metamorphosis.

I conceive that Dr. Pagenstecher's apparently well-established proposition (that "only such Trematode larvæ as are capable of arriving at sexual maturity are furnished with special appendages") gives strength to my views regarding the recognisable epochs in the fluke-individual's life, and points to the line of origin, continuity, and definiteness of the third "biotome" which I have recognized on totally independent grounds.* There is about the same relative amount of individualised-being in the caterpillar, pupa, and imago states of the Insect, as there is in the cercaria, pupa, and fluke conditions of the Trematode; but the "epoch" of the one embraces the whole life of the "zoological individual," whilst in the other it represents only a section, or "biotome," of the life-cycle. If the term "zoöid" be not allowable for the separate metamorphosed life-phases, as well as for true gemmæ, some other distinctive nomenclature must be substituted. I would like to see it retained to designate the semi-individualised, separable life-phase, without regard to its peculiar mode of genesis.

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* See Pagenstecher's "Schlussbemerkungen" (*loc. cit.*, p. 29 of the present work).

Practically, other curious results arise out of the foregoing considerations. For example, a single sheep may harbour 1000 flukes. Each fluke may develope 10,000 eggs. Each egg may give rise to 370 zoöids. It thus appears that, if all the conditions were favourable, a single fluke might originate between three and four millions of individualised life-forms; whilst the solitary sheep itself would, under the same circumstances, be the means of causing the production of at least 3,000,000,000 fluke-zoöids! Happily, no such result as this can possibly occur in nature, since a multitude of "interfering agencies" reduces the "favourable conditions" to a comparatively small number. However, the balance of parasitic forms from all sources is sufficient to destroy thousands of sheep annually—to say nothing of the wounds inflicted on millions of small mollusks, into whose bodies the "zoöids" penetrate.

Reverting to the Cestodes, the results attainable from particular species are, in some respects, still more striking. Let us separately examine the "zoological individuals" of *Tænia cœnurus* and *Tænia echinococcus*. The life-phases of the former may be tabulated as follows:—

ZOOLOGICAL INDIVIDUAL (*Tænia cœnurus*).

a. Ovum in all stages.	First "biotome."
b. Six-hooked embryo, boring larva, or *proscolex*. .	
c. Resting, polycephalous larva (*Cœnurus cerebralis*).	
d. Sexually immature tapeworm.	Second "biotome."
e. Mature tapeworm colony, or strobile. . . .	
f. Segment, free-joint, or *proglottis*. . . .	

At first sight, this representation appears to be the same as that of the *Tænia serrata*, already given. It is, in truth, zoologically equivalent, but the component life-phases are both structurally and numerically different. The "resting larva" of *Tœnia serrata* consists of a single free scolex, whilst the "resting larva" of *T. cœnurus* comprises a multitude of conjoined, inseparable *scolices.* In the one case the scolex is a true "zoöid," in the other it is the merest fraction of a "zoöid." In the case of *Tœnia serrata,* one single egg, under the most favourable conditions, can only lead to the development of one tapeworm; but, under like circumstances, the single egg of *Tœnia cœnurus* may lead to the formation of at least 300 tapeworms. This is accomplished when the *Cœnurus* of the sheep's brain is transferred to the stomach of the dog, and all the scolex-heads with which it is furnished become developed into tapeworms. If we call to our aid an estimate of the "zoöids," the result is very much more significant. On the plan of interpretation previously adopted, the "zoological individual" of *Tœnia serrata* (allowing 500 proglottides for the strobile) would only yield us 503 "zooids" (as I have defined them); but in the case of *Tœnia cœnurus* this representation would certainly give us as many as 1,500,000 "zoöids." Then, as regards the total number of eggs produced by all the final "zoöids" collectively, we should, in the case of *Tœnia serrata* (allowing each proglottis to contain 5000 ova), obtain the comparatively small total of 2,500,000 eggs; whilst in the case of *Tœnia cœnurus,* the progeny of a single germ would collectively give out no less than 7,500,000,000 ova!

Lastly, let us glance at the possible results derivable from a consideration of the "zoological individual" of *Tœnia echinococcus.*

ZOOLOGICAL INDIVIDUAL (*Tœnia echinococcus*).

a. Ovum in all stages. . . . .
b. Six-hooked embryo, boring larva, or proscolex. . } First "biotome."
c. Resting, acephalocystic larva (hydatid). . .
d. Sexually immature tapeworm. . . . . .
e. Mature tapeworm colony, or strobile. . . . } Second "biotome."
f. Segment, *proglottis,* or free-joint. . . .

Here, again, the representation is as simple as obtained either in the case of *Tœnia serrata* or in that of *Tœnia cœnurus*; but, in point of numerical and structural detail, the life-phases are remarkably different. Here, the "resting larva," as in *Cœnurus*, is furnished with a multitude of "heads;" these, the latter, being the well known echinococci or scolexes developed in a rather more complete form than occur in *Cœnurus cerebralis*. In fact, the so-called "heads" are almost separable "phases," being attached to the maternal larva by slender pedicles only. They are, indeed, frequently found detached; but then it is questionable if they have not already parted with their vitality. In this view I cannot call them "zoöids"; but the daughter-hydatid formations, which are developed within or without the original maternal hydatid, are quite deserving of such distinction. The latter are separable, organized life-phases, each of which, like its parent, may develope a multitude of echinococci; so that, under favourable conditions, there is practically no limit to the number of "heads" which may be generated by a proliferating hydatid; consequently, also, there is practically no limit to the number of tapeworms liable to be developed from the same source. The strobiles in this case, however, have only three joints capable of arriving at sexual maturity; at least, only the lowermost of these is mature at one and the same time. Whether or no the Tæniæ are susceptible of indefinite proglottis-multiplication, after the fashion of ordinary tapeworms, is a point on which I am, at present, uninformed; it is probable, however, that the joints follow the ordinary law of successional development. In either case our computation of the number of zoöids and eggs capable of arising from a single germ need not be affected by this consideration. Taking an average case of hydatid development, and assuming the existence of conditions favourable to the complete development of the entire progeny, a single germ of *Tœnia echinococcus* might, without any exaggeration, give us between five and six million separate life-phases, or "zoöids," from which, under like circumstances, there would result not less than 150,000,000,000 ova! In this calculation I do not take into account the probability of each hydatid tapeworm or strobile developing more than three successive sexually mature segments, and I allow for each proglottis (tetartozoöid) only 10,000 eggs. For each hydatid I allow 10,000 scolices; though, doubtless, one large acephalocyst might develope ten times that number. As many as a thousand hydatids, may be discovered in the body of a single "host"; but, according to my experiences, the echinococcus-heads are not usually present in more than a limited number of the numerous daughter vesicles. If the hydatids were less "cribbed, cabined, and confined" than is commonly the case, no doubt can be entertained that their power of proliferating and of producing the so-called "heads" or scolices would be correspondingly increased.

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ERRATA.

In addition to the few errors indicated at the first page of this work, I have to point out the following:—

At page 103, line 9, for "with aquiferous," read "with the aquiferous."

At page 153, line 10, for "naturally lead," read "naturally leads."

At page 270, line 2 and elsewhere, for "Naumyn," read "Naunyn."

At page 279, line 8, for "Baillinger," read "Baillarger."

At page 286, line 12, for "were are," read "we are."

At page 313, line 10, for "of Dyer," read "of Professor Robert Dyce."

At page 337, line 15, for "Valentine," read "Valentin;" and at line 19 of same page, for "Rupprecht Fiedler," read "Rupprecht and Fiedler."

At page 339, in the footnote, for "Dr. Lieving," read "Dr. Liveing."

At page 369, line 8, for "and its tail, without exception, the flattened," read "and the tail are applied to the flattened side of the egg."

At page 442, in the Bibliography, for "Dyer," read "Dyce."

And at page 472, line 3, for "Roy. Soc.," read "Ray Society."—T. S. C.

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